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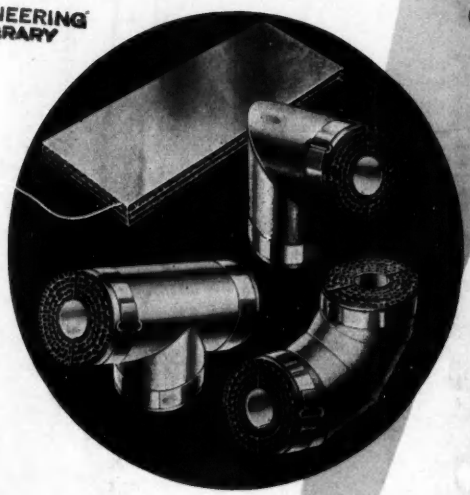

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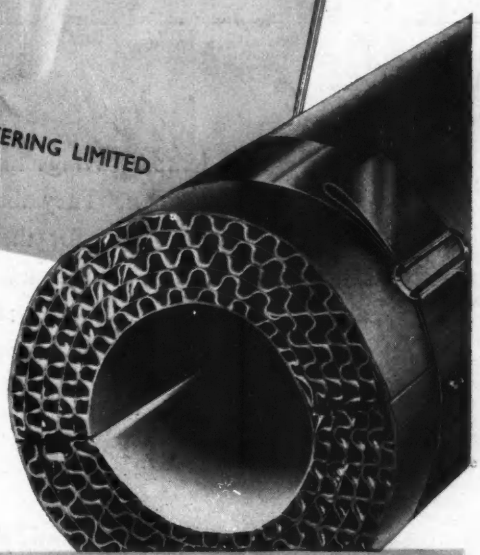

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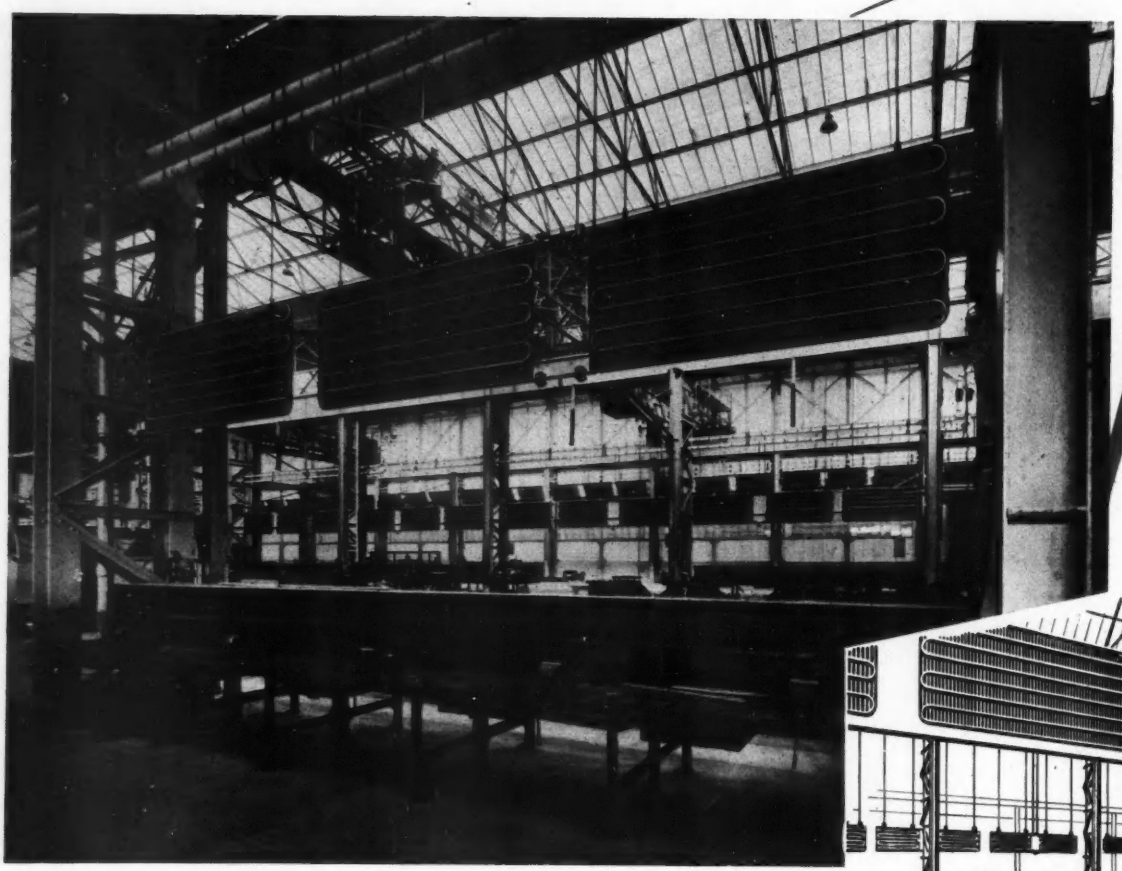

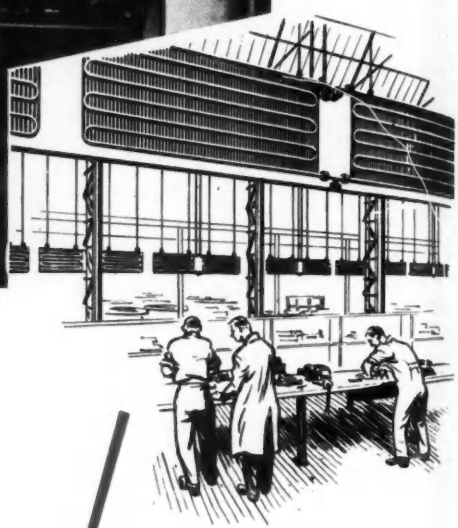

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THE ENGINEER

VOL. 202 No. 5251 SEPTEMBER 14, 1956

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OUR ROADS ARE PERILOUS

Recently, when inaugurating the Institute of Advanced Motoring, the Minister of Transport is reported to have said: "Driving so as to cause no risk of harm to oneself or to others demands concentration, a high degree of skill and anticipation, a full sense of responsibility, unselfishness and, not least, a realisation of one's own limitations and those of others." In so far as he was speaking of British roads he under-stated his case. But what a catalogue of human virtues he had to mention! Is there a single road user, a single driver, who, with his hand upon his heart, dare proclaim that never, never, never does he stray from so strict a path of virtue? Angels live in Heaven. They do not drive motor vehicles on earth! Yet British roads lay upon those who drive upon them responsibilities that no man of less than saintly character should be asked to bear. Within every few hundred yards the driver is called upon to make snap judgments of speed, distance, acceleration and the reactions of others. Is that bend ahead only as sharp or much sharper than others already negotiated? This road has become narrower but straighter than before. Is it justifiable to maintain speed? Is there room for two vehicles to pass on that hump-backed bridge blocking the view ahead? Has this car sufficient acceleration to pass the one ahead before the bend is reached? Is there room simultaneously for this car, the cyclist ahead and the car coming the other way? Is the cyclist a nervous type, likely to swerve? The baby car ahead will never pass the coach on this winding road. Dare an attempt be made to pass both in one rush of acceleration? Or does one trail along behind indefinitely? That fellow in front coming my way has misjudged his acceleration and won't get past the coach; on with the brakes! Can the right turn be made across the bows of that car coming the other way? How fast is he moving? How quick shall I be? How long a wait will be entailed if the opportunity is missed? Some of the decisions have even to be based upon a subtlety of observation that should be demanded of no man. That right-hand curve ahead is not very sharp; brake, though! The road camber is steeper there than elsewhere. Is there anything to wonder at that 5526 people were killed on the roads last year and over 62,000 seriously injured? Are road-users, sorely tried and expected to behave always, and with never a let-up, like saints, really to blame? For our part we do not believe it. There may be a class of dangerous drivers who are accident prone. But if so, it must be very small. The majority of serious accidents are suffered by road users who have never before experienced one. Chance is the ruling factor, the chance that two people simultaneously make misjudgments or if only one is involved that the misjudgment is made at the particular moment or place when its consequences must be serious. British roads offer chances of misjudgment in such profusion that no road user can hope to do better than make as few as possible per year. There is merit in an accident-free record but not great merit. Luck has played its part as well. There must be few experienced and accident-free drivers who cannot remember incidents in the past when "but for the Grace of God..."

Yet why should travel upon the roads be so perilous that 5526 people were killed upon them last year? The clear answer, as every highway engineer knows, is that, though death on the roads can never be wholly eliminated, it could be reduced to a far more modest figure annually. It is not so reduced solely because the Government will not recognise the urgency of building new roads. How strange! When, in the middle of the last century, accidents on the new-fangled railways multiplied, people and Government combined to insist not that train speeds should be lowered, not that drivers should be blamed, but that, by expenditure on signals and equipment generally, safety should be improved. The means was found to lie in reducing the opportunities for railway servants to make misjudgments. In air travel, too, the same principle rules. Wherever possible a pilot is provided with such ample information that it would be difficult for him to go far wrong and airfields are equipped at high expense with every device that can enhance the safety of the aircraft and passengers. So, too, in the operation of ships. At great expense lighthouses and beacons are maintained to guard the coasts, direction finding equipment aids the navigator, radar reveals dangers at night and in fog. The possibility that misjudgment may hazard lives is reduced as far as human ingenuity can reduce it. Only upon the road is the wretched user expected to operate without all the aids that the engineer

could give him. Yet it is upon the roads more than anywhere else that every aid that can be offered should be given. The driver of an express train and the signalman in an important box are specially selected men trained for the job; so, too, are the pilots of aircraft and the airfield controllers in their towers, so, too, are the captains and officers of ships. But all and sundry use the roads. No wonder there are accidents. The ordinary mortal is expected to make correctly as many snap judgments in a single day as a ship's captain, an aircraft pilot or a train driver will be called upon to make in a lifetime. He cannot be expected to prove always equal to the task. What can be done and what should be done is to reduce as far as possible the number of his opportunities to misjudge. That is an object that can only be achieved by building new roads, within cities as well as across country, fit to bear the weight and speed of the traffic they will carry. Thousands of lives would have been saved had they been built years ago. Highway engineers are itching to build them. Apart from humanitarian considerations, the economic justification for them is abundant. But unless indeed the control of road building can be removed from Governmental hands, we doubt whether an energetic campaign of road building will ever emerge until a man is made Minister of Transport with character enough not to regard his post as merely a stepping-stone to something higher, and force enough to insist that his Ministry is amongst the most important in the Government.

A.T.C. AND THE MILTON DERAILMENT

Some years ago we published a series of articles under the general title of "Historic Accidents and Disasters"; it covered shipwrecks, railway collisions, and such like, and naturally included the catastrophe of the first Tay Bridge. The accidents chosen for inclusion in the series were those that brought to light weaknesses in engineering design, faults in operating practice, and which, in some cases, formed the starting point for an important chain of development. The details of the accidents themselves, often gruesome, were regarded as secondary in interest and importance to the causes. In the history of railway accidents the derailment at Milton, near Didcot, on November 20, 1955, will probably take no more than a relatively minor place; for although there was loss of life and much damage to rolling stock and permanent way the cause was simple enough. The driver of the train concerned missed the distant signal approaching Milton Box, and so was unprepared for a diversion to the goods loop line; he ran through the crossover road much too fast, and the engine and three coaches went down the embankment. Naturally, a great deal of Brigadier Langley's report deals with his investigations to see if there were any extenuating circumstances that could account for the driver's lapse, particularly as the locomotive was fitted with automatic train control apparatus. But the load of the train was relatively light, the schedule easy, and the running conditions generally good. On the other hand, the driver failed to read that part of the Weekly Notice issued on the previous day that advised of the Milton diversion; he failed to check the working of the A.T.C. apparatus when his engine left the shed at Cardiff, and finally, having missed the critical distant signal at Milton, he failed even to see the home signal until he had almost reached the facing points. Brigadier Langley found all the signalling and A.T.C. apparatus in perfect order, and placed the responsibility for the accident entirely upon the driver.

In the course of the investigation, however, a number of rather disturbing facts were brought out, mostly concerning the locomotive. The "Britannia" class "Pacifics" have been the subject of much comment ever since their first introduction in 1951; this comment mainly concerned the unfortunate teething troubles that were experienced with wheels shifting on the axles, and with failures of coupling rods. The Milton report draws attention to another feature of these locomotives, well enough known among those who have travelled on them, namely, the excessive noise, dirt and general discomfort experienced while on the run. Locomotive enginemen as a race are used to "roughing it"—indeed, some hardy spirits have expressed misgivings about the softer life that lies ahead of them in the electric and diesel age; but there are degrees in everything, and two motive power inspectors who gave evidence at the inquiry said that it was difficult to hear the A.T.C. bell and siren due to the noise in the cab at speed. With so many quiet-riding and comfortable engines at work in this country it is surprising that the "Britannias" should be so disagreeable in this respect, though it is not merely a matter of discomfort. Due to the conditions existing in the cabs the A.T.C. sirens were inclined to get dirty, and when this occurred they sounded weakly. This may have been the case at Milton distant signal, though the acknowledging lever must have been operated to prevent the automatic brake application. The driver's evidence on this point provides a tragic parallel to the Aisgill disaster of 1913, which was one of the accidents discussed in our earlier series; he was distracted by the fireman having trouble with the exhaust steam injector, just as the Midland driver had been forty-two years earlier. It was said, then, that some form of audible cab signal would have prevented the Aisgill accident; it did not, unfortunately, prevent the Milton one, though, as Brigadier Langley emphasises: "Accidents caused by the disregard and subsequent unthinking cancellation of the A.T.C. warning and braking effect have been very rare indeed, and a mistake of this kind has featured only once before in a formal inquiry."

The tests on the A.T.C. equipment of the wrecked engine "proved its integrity beyond all doubt"—again quoting the report; but the fitting of the G.W.R. type of A.T.C. to British standard locomotives of various types that are allocated to the Western Region was at first not entirely satisfactory. Improvisation is apt to bring risks in its train, and when the B.R. standard locomotives were allocated to the Western Region and fitted with the G.W.R. type of A.T.C. equipment a fundamental difference between the braking arrangements on B.R. and W.R. locomotives seems to have been overlooked. Whereas the Great Western air pump, which maintains vacuum while running, is isolated from the train pipe by means of a vacuum retaining valve whenever there is a reduction of vacuum in the train pipe, on the B.R. engines the small ejector remained in action during an A.T.C. brake application. The brake application was thus much less effective on B.R. engines. This feature was soon noticed by the running staff, and an automatic ejector isolating element was designed, which, when fitted to B.R. engines, greatly improved the brake performance under A.T.C. application. This ineffectiveness had no bearing upon the course of events at Milton, since the brake application was cancelled entirely, in some way that the report was not able to establish. The possibility of an irregular cancellation of an A.T.C. application has been an acknowledged weakness in the G.W.R. system, yet one which was fully realised and accepted by the operating authorities on the railway concerned. The system now being developed for British Railways goes one stage further by including a visual indication, and when an A.T.C. application has been received, it is not possible to cancel this visual indication which remains before the driver as a reminder of what the last A.T.C. indication received was. It remains, moreover, until the next A.T.C. location is reached, and a warning is only cancelled then, if the second indication is "all clear." This device certainly provides an additional safeguard, and we are interested to see that Brigadier Langley recommends its addition on Western Region locomotives, if it is possible to do so without impairing the efficiency of the apparatus in any way. The G.W.R. system has given service that has been, and still is, of inestimable value in the operation of fast and heavy traffic; this additional safety feature would further enhance its value.

A Seven Day Journal

"Electrical Energy"

We have pleasure in welcoming a newcomer to the technical press. The first issue of *Electrical Energy* has just been published by Morgan Brothers (Publishers), Ltd. It may seem strange to add another to the several journals already covering the electrical engineering field. But the editor of the new journal points out that great technical advances have been made, more particularly since the war, within the field of electrical engineering. Thirty or forty years ago, he says, "the transformer, the alternator and the d.c. machine formed very largely the sum total knowledge of the electrical engineer of the time." But "the modern electrical engineer must have a much broader knowledge and wider vision if he is to keep abreast of new techniques and developments." The journal is intended for the professional electrical engineer engaged in research, development, design and manufacture. It will maintain a standard in the articles contributed to it comparable with that of the articles appearing in *Electronic Engineering* and will be under the same editorship. It will appear monthly at a price per issue of 3s.

Conference on Fatigue of Metals

This week there is being held, in London, an international conference at which the fatigue of metals is being studied. It is sponsored by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers, and a "follow-up" conference has been arranged to take place in New York in November. When the arrangements for the conference were first being discussed, it was recognised that much of its value would depend on obtaining representative contributions from overseas, and the technical committee responsible devoted considerable attention to the possibilities of the international aspect of the conference. As a result, contributions have been received from Australia, South Africa, France, Germany and Japan, as well as from the U.S.A. The conference opened last Monday morning when an introductory address was given by Dr. H. J. Gough. The text of this address, entitled "Changing Nature of the Fatigue Problem," is printed on page 359 *et seq* of this issue. Subsequently, at the various sessions of the conference, the papers have been presented in groups under the general headings of stress distribution, temperature frequency and environment, metallurgical aspects of fatigue, basic studies, and engineering and industrial significance of fatigue. The conference ends this (Friday) afternoon, when the reporters for the groups will review the proceedings and summarise the problems which remain to be solved.

Harwell Reactor School

On Monday, Sir John Cockcroft, director of the Atomic Research Establishment at Harwell, opened a new building to house the Harwell Reactor School. This building will enable more students from this country and overseas to be accommodated. It has also enabled the school to increase the number of courses to meet the demands of industry, universities and technical colleges. The first course of the new session has started this week, and is being attended by twenty overseas students from thirteen countries, twenty students from British companies and universities, and by about fifteen members of the Atomic Energy Authority's staff. These students will receive a three-months' course of instruction which includes about 150 lectures, each of one hour's duration, and visits to various nuclear reactors which are either in operation or under construction. The students will also perform various experiments, many of them involving the use of the Harwell reactor BEPO, and all of them concerned with the measurement of physical and engineering data necessary for reactor design and construction. This standard three-months' course is arranged to give graduate engineers and physicists a good general background in reactor technology. It is intended primarily for the larger companies which are now engaged in the implementation of the nuclear power programme, and for foreign students. In addition, the U.K. Atomic Energy Authority has announced that, for the first time since the school opened two years ago, there is being offered concurrently with the three-months' course one of six weeks' duration. In fact, it is the first six weeks of the standard course, and is concerned mainly with the fundamental physical and engineering principles in reactor design. It is expected that the six-week course will interest mainly lecturers from universities and technical colleges, and the staffs of firms working on ancillary aspects of the nuclear power programme.

The Engineer

100 Years Ago

(SEPTEMBER 12, 1856)

"Fires in London"

"So numerous of late have been the fires occurring in the metropolis, and so disastrous the results in the majority of cases, that our attention has naturally been called to the question of the adequacy of the means at present employed for extinguishing them when they have, unfortunately, broken out. This is only, however, one side of a larger question; prevention is acknowledged to be better than cure, and while we admit that every effort should be made to construct buildings fire-proof, yet it is a most important point to be well-provided with means to extinguish fires in buildings already erected, and which could not without great cost, be rendered anything like safe. . . . Our immediate object is to point out what should be done for arresting the destruction of property, when once fairly in flames, and this, we most positively state, could be done without difficulty, by the use of steam fire-engines . . . .

"No-one who has watched the insignificant squirting of ordinary engines, and compared it with the powerful jet of the steam floating engine, can perhaps duly appreciate the vast superiority of one over the other; and those who have seen the difference have, doubtless, asked themselves how it is that steam power cannot, or rather is not, used in land engines as well as in the floating ones? Such persons would quiet themselves by immediately supposing that there were some difficulties in the way, of a mechanical nature, such as the weight of the machinery or boiler; or would, at any rate, think of every possible cause except the right one—this being nothing else than that of the pipes, or openings into the streets, being too small to give an adequate supply of water! The mains are, of course, ample in size, but the short lengths of pipe which lead from the mains to the surface of the streets are wholly unequal to the supply of the quantity of water which these powerful suckers require for their due performance. The question, then, rests with the Water Companies, or between them and the Insurance Companies. . . . Certain it is that the inhabitants of large towns especially should bestir themselves, and act in this important matter."

Some Problems in the Purification of Sewage

The new president of the Institution of Public Health Engineers, Mr. Sciver, delivered his address to that Institution last Tuesday. Mr. Sciver, who is a consulting chemist and bacteriologist, said that he thought he was the first president of the Institution who was not an engineer, but he believed he would be able to contribute something useful to the Institution's proceedings, as a member of a closely allied profession. In commenting upon contemporary problems in the purification of sewage, the first point which he made was a plea for the greater use of hydraulic models by designing engineers. It was surprising, he said, how little use was made of working scale models of such things as sedimentation tanks, by designing engineers, and he thought that better results would be achieved by their use and better tank design would result. The preparation of glass models or pilot plants was quite common practice, he continued, when a chemist or chemical engineer wished to convert a laboratory process to full-scale manufacture. Mr. Sciver also thought that the knowledge and experience gained in manufacturing chemistry might be taken advantage of by public health engineers, by adopting the centrifuge to cut short the costly process of sedimentation. He thought that a centrifuge could be developed capable of separating the suspended matter from sewage at least as efficiently and far more quickly than any sedimentation tank yet constructed. Mr. Sciver then made some remarks on the discharge of crude sewage into the sea. That really disgusting process, he said, went on all round our coasts, and he drew attention to very high counts of bacteria of faecal type found in sea water on or just off popular bathing beaches. Almost all the sea water available for bathing was polluted to a degree that would be considered dangerous in an inland swimming pool. A great many of our rivers, Mr. Sciver continued, were in a condition which could only be described as a disgrace to our civilisation. All this continued in a country which prided itself on its high standards of sanitation. On more than one occasion he had had to report that local authorities were as much to blame for river pollution, because of their inefficient sewage works, as the traders by reason of their trade effluents. The cost of reasonable treatment of a trade effluent was not an undue burden on a manufacturer, he asserted. On two recent occasions he had found manufacturers to be discharging in their trade effluent several tons of sugar per week; a similar thing often happened when milk was used or processed.

Obituary

ENGINEER VICE-ADMIRAL SIR REGINALD SKELTON, K.C.B.

WE record with regret the death of Engineer Vice-Admiral Sir Reginald Skelton, which occurred, on September 5th, at Meadow Cottage, Aldingbourne, Sussex. Sir Reginald, who was eighty-four, was Engineer-in-Chief of the Fleet from 1928 to 1932.

Sir Reginald, who was the third son of Mr. William Skelton, of Long Sutton, Lincolnshire, was born in June, 1872, and was educated at Bromsgrove School before joining the Royal Naval Engineering College at Devonport in 1887. In 1892, after completing the course, he was appointed assistant probationary engineer and during the next eight years served in a number of ships. Sir Reginald's next appointment was to superintend the building of "Discovery" for the National Antarctic Expedition and he was chosen by the late Captain Scott to accompany the expedition as chief engineer of the ship. For six years, from 1906, he was engaged in the submarine service, and then he served in H.M.S. "Superb" until the outbreak of the first world war, when he joined H.M.S. "Agincourt," with the rank of Engineer Commander. Admiral Skelton was present at the Battle of Jutland and was awarded the D.S.O. and also the Russian Order of St. Stanislas for his conduct on that occasion. In the succeeding years he served as Fleet Engineer Officer, Mediterranean Station, and then in the same capacity in H.M.S. "Elizabeth" on the Atlantic Station. He continued to advance in his career and became Engineer Rear Admiral in 1923, and Engineer Vice-Admiral in 1928 upon his appointment as Engineer-in-Chief of the Fleet. He relinquished this appointment upon his retirement in 1932. In 1936, he joined the board of directors of John I. Thornycroft and Co., Ltd., and continued to be associated with the company until his death.

SIR RALPH WEDGWOOD, Bt.

SIR RALPH WEDGWOOD, whose death occurred at Leith Hill Place, near Dorking, on September 5th, at the age of eighty-two, will be remembered by his long and distinguished career in railway management and operation. He was general manager of the London and North Eastern Railway Company from its formation in 1923 until 1939.

Sir Ralph was educated at Clifton and at Trinity College, Cambridge, and joined the North Eastern Railway Company in 1896. He spent three years in the dock superintendent's office and then became an assistant in the general traffic manager's office. In 1902, Sir Ralph was appointed district superintendent at Middlesbrough. For a short time subsequently he was secretary of the North Eastern Railway Company, and in 1911 he became assistant goods manager at York, afterwards succeeding Sir Eric Geddes as chief goods manager. In the first world war, Sir Ralph was Director of Docks in France. After the war he returned to the North Eastern Railway as general manager. With the grouping of the railways in 1923, Sir Ralph was appointed chief general manager of the London and North Eastern Railway, a position which he relinquished in 1939 when he became chairman of the Railway Executive Committee. Among his many other services, Sir Ralph was a member of the Weir Committee on main line electrification (1930–31) and a member of the Central Electricity Board from 1931 to 1946.

Parking in the U.S.A.

No. I

By H. J. H. STARKS, B.Sc., Ph.D., D.I.C., F.Inst.P*.

The rapidly increasing number of vehicles in use in the United States of America is creating serious parking difficulties in many cities. One of the consequences is the development of suburban shopping centres, and this is having serious repercussions on the commercial activities of the central business areas. To counteract these trends and to meet the insistent demands for more parking accommodation, some cities are making great efforts to solve their parking problems. This article considers the parking problems in American cities and describes some measures directed towards their solution. These include the use of parking meters for steet parking, off-street parking sites, multi-storey open-deck garages with ramps or hoists for inter-floor movement, large underground car parks, mechanical parking of cars, car storage on the roof or upper floors or in the interior of buildings, and fringe parking. Information is given on the costs of providing these facilities, on the charges made for parking and on the methods used for enforcing the parking regulations.

THE answer to the question "Where can I park my car?" is one which presents many Americans with a daily problem, often involving inconvenience and delay. The recent rapid growth in the number of cars has created an increased demand for parking space, and much of this has had to be met by street parking, leading to greater traffic congestion, particularly in the business and shopping areas of cities. The conflicting requirements of shoppers who wish to park for short periods, of business people who wish to park all day and the demands of moving traffic make the parking problem one of great complexity.

Fig. 1—Parking sign in Washington, D.C.

The Federal Aid Highway Act of 1944 encouraged cities to improve their main arteries by providing money for this purpose from Federal funds; these funds, however, could not be used to build car parks. Parking facilities have had to be provided from the cities' own resources or by private enterprise, and it is obvious that insufficient money has been allocated for this purpose. One of the consequences resulting from inadequate parking space has been the growth of suburban shopping centres, where ample parking facilities, often free, cater for the needs of many who formerly shopped in the central areas of the city. The financial repercussions on the shops and stores in the central area have, in some cases, compelled large stores to close or to move to one or more suburban sites; property values in the central area have in consequence declined appreciably. The central areas of cities are, however, still the hubs of commercial activity, and municipal authorities are realising that active steps must be taken to provide more parking facilities if a further decline is to be avoided. As a result, many American cities are carrying out surveys of their parking requirements and are preparing plans or taking immediate action to meet them.

Parking difficulties are not confined to American cities, but are being experienced in most large cities in Britain and in other countries. The way in which the parking problem is being attacked in the United States is therefore of special interest. This article describes some of the measures taken in the United States and is illustrated by photographs taken by the author during a visit to the United States in 1954–55.

THE PARKING PROBLEM IN AMERICAN CITIES

The parking problem in the United States, compared with that in other countries, is aggravated by the following factors:—(1) There are more cars per head of the population—there are about 55,000,000 cars or about one car for every three inhabitants; (2) American cars are longer and wider than most common makes of car in other countries; (3) most Americans prefer to use their car even if this means inconvenience and delay; as a result, public transport companies cannot offer as good a service as they might wish, except by charging exorbitant fares; this in turn tends to encourage people to use their cars rather than public transport; (4) few shops deliver goods and therefore shoppers have to use their cars to take home purchases, particularly groceries; (5) many car owners do not possess a private garage and many who have do not use it; most people leave their cars in the street. On the other hand, the streets in most cities in the United States are much wider than in Britain, so that cars parked at the kerb do do not cause the same degree of congestion as in Britain.

The magnitude of the demand for parking space in most cities in the United States is obvious even to the most casual observer. Both sides of streets on which parking is not prohibited are usually lined with cars (Fig. 2) and off-street parking accommodation is frequently filled to capacity. The

* Road Research Laboratory, Department of Scientific and Industrial Research.

Fig. 2—Street parking in Washington, D.C. (N. St., N.W.)

Fig. 3—Parking on space between buildings, Washington, D.C. (K. St., N.W.)

ground between buildings (Fig. 3) and the yards at their rear (Fig. 4) are also often filled to capacity. In most cities the regulations governing the places where cars may be parked and the duration of parking are clearly displayed, but in spite of this the number of offences for street parking greatly exceeds that of all other traffic offences combined. In Washington, for example, drivers prosecuted for parking offences numbered 30,000 in 1954 and about 50,000 in 1955. It is interesting to note that in 1954 about 30,000 people were prosecuted and 28,000 received written warnings for obstruction in the London Metropolitan Police District.

In Pittsburgh all street parking is prohibited in the business area between 7.45 and 9 a.m. and between 4.30 and 6 p.m., except to pick up waiting passengers ; during the rest of the day parking is limited to ten minutes. This regulation is strictly enforced and cars exceeding this period are liable to be towed away by the police at the owners' expense. In many cities street parking is permitted in most streets, but, except at weekends, the maximum permissible parking period in the business area during the day rarely exceeds two hours. Most cities have regulations forbidding the construction of new office or apartment buildings or large stores unless certain prescribed parking facilities are provided. In spite of these regulations, however, acute parking difficulties are encountered near some of the newly erected apartment buildings.

Parking Facilities

Street Parking—In the United States, as in other countries, there are restrictions on parking in the streets of cities. These restrictions are much more clearly signposted in American cities, and signs are often put up at intervals of a few yards (Figs. 1 and 6). A visitor from abroad is usually struck by the veritable forest of signs relating to parking. Although many American drivers are prosecuted for overstaying the permitted parking period, few are prosecuted for obstruction by parking in streets in which there are no signs regarding parking, as is often the case in Britain. Apart from streets where it is permissible to park a vehicle at the kerb, clearly defined parking spaces are provided in many city streets ; these usually have parking meters (Fig. 5) ; there are over 1,000,000 of these in use in the States.[1] Generally, there is one parking meter for each parking space, but in some municipal car parks one meter caters for every two vehicles. A coin is inserted in the meter and this starts a clockwork mechanism which shows the unexpired time on a scale. A red indicator appears when the permitted time limit has expired. The charges vary considerably, ranging from about 5 cents per hour to 40 cents per hour. In some cities, provision is made for short-period parking by charging 1 cent for each twelve minutes, the driver inserting the appropriate number of coins depending on the time he expects to park. In some cities, the revenue from parking meters is used to provide more off-street parking facilities ; in others, particularly the smaller cities, it merely provides an additional source of income.

If parking meters are to serve their proper purpose, it is essential that there shall be a proper system of enforcement. This sometimes presents a difficult problem in cities where there are several thousand meters. In Washington, police patrols

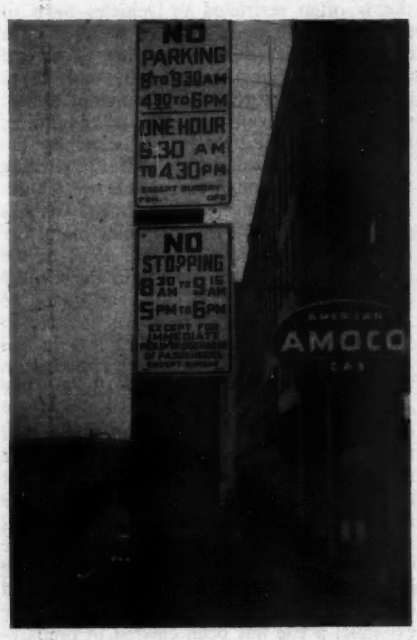

Fig. 6—Parking sign in Pittsburgh, Pa.

Fig. 4—Parking in yard at rear of office buildings, Washington, D.C. (K. St., N.W.)

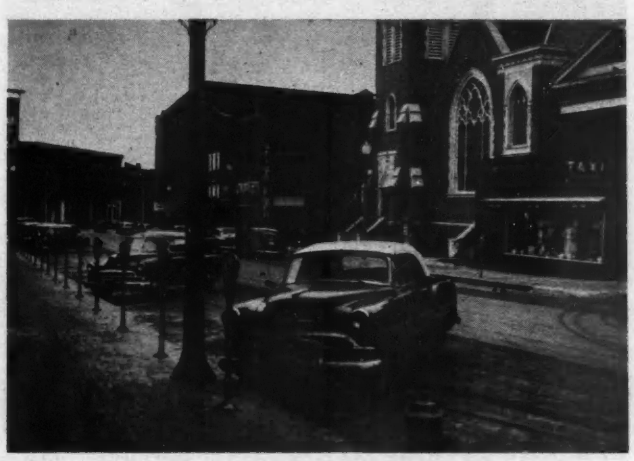

Fig. 5—Parking meters in Bennington, Vt.

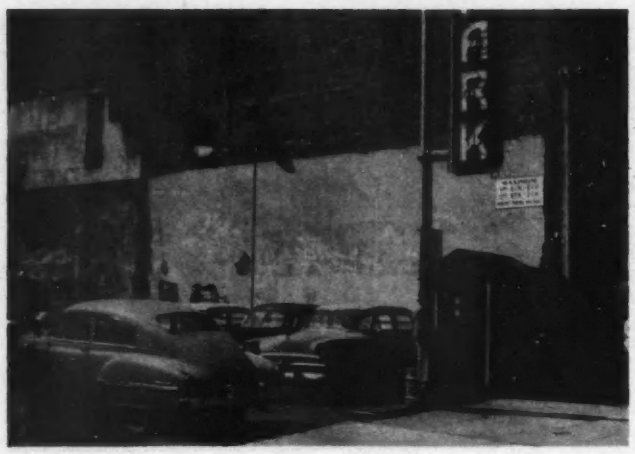

Fig. 7—Off-street parking lot in Washington, D.C. (Connecticut Avenue)

Fig. 8—Off-street parking lot with hydraulic hoists, Washington, D.C. (G. St., N.W.)

mounted on motor-cycle combinations periodically inspect the parking meters. Although the insertion of coins in a parking meter allows a vehicle to be parked for a stated time, there is nothing to stop the driver from inserting more coins before or when the allotted time has expired. In some cities, the police periodically mark the tyres of parked cars with chalk to detect those who offend in this way. Most parking meters require the use of 1 or 5 cent coins. Shopkeepers in several cities have complained that they are continually pestered by drivers requesting change. In one large municipal park, it was found that the provision of a change-giving machine resulted in a 60 per cent increase in the daily sum collected from the parking meters.

Where the street is wide enough and the traffic conditions permit, parking meters are usually arranged for diagonal parking, usually at an angle of 45 deg. or 60 deg., and vehicles drive in and reverse out. The spacing of the meters is usually about 10ft for diagonal parking and about 24ft for parking parallel to the kerb. It has been found to be desirable to mark the parking stalls, especially when diagonal parking is used. A study made in Washington by the American Automobile Association[2] showed that the average time taken to park at the kerb with no stall markings was about thirty-eight seconds, but to park in marked stalls, the average time was about twenty-two seconds. The time taken to unpark from marked stalls was also shorter.

Off-Street Parking Lots.—In cities, parking areas or lots are open spaces on which the maximum number of cars is crammed. Their appearance is seldom attractive (Fig. 7), and were it not for their useful function in getting vehicles off the streets they would probably not be tolerated. Access to the site is often restricted or vehicles have to cross the pavement, and the removal of a car usually requires the moving of several other cars. Generally, an attendant takes delivery of the car at the entrance of the lot and delivers it again when the driver requires it. Cars cannot usually be locked by the owner. The attendants are skilful in parking vehicles and although complaints are seldom made about damage, the treatment vehicles receive is probably rougher than many car owners would like. These are some of the inconveniences which drivers in the United States suffer because of the inadequacy of parking space. So great is the demand in some cities that some parking lots in the business areas are now resorting to elaborate devices for increasing parking space. For example, hydraulic hoists of the type usually employed in service stations are being used to double the number of cars that can be stored on a given area (Fig. 8); the first cars to arrive are lifted up by the hoists and later arrivals are parked underneath, so that there are two rows of cars, one above the other. The great demand for parking is an incentive for property owners and others to provide parking space when, for example, a site has been cleared in preparation for new building construction. This affords a welcome, even if temporary, addition to the parking facilities.

Although the layout of most parking lots can hardly be said to have been designed, some cities have made regulations or recommendations regarding the minimum widths of access. In New York, for example, the following minimum widths of the entrance and exit are recommended :—

Size of parking area :	Minimum width of entrance and exit :
24 spaces or less	One 8ft lane
25–50 spaces	One 10ft lane
51–300 spaces	Two 10ft lanes
For each additional 150 spaces (or fraction thereof)	One additional 10ft lane

A review of the off-street parking requirements for new buildings considered desirable by the local authorities of some forty cities is quoted by The American Automobile Association[2] as follows :—

Type of building :	One parking space required for each :
Theatres	7 seats
Retail business	400 square feet
Office buildings	450 square feet
Industrial buildings	3 employees or 750 square feet
Restaurants	5 seats
Hotels	4 guest rooms
Single dwellings	1 unit
Multiple dwellings	1½ units

The requirements differ considerably in different cities and the above figures are quoted as averages. Detailed information is given in a publication by the Highway Research Board.[3]

The New York Regional Plan Association[4] makes the following recommendations regarding street loading bays for commercial

Fig. 9—Parking on waterfront, Pittsburgh, Pa.

Fig. 10—Parking on waterfront, Pittsburgh, Pa. (Note large parking areas round office buildings)

vehicles serving department stores, warehouses, office buildings or hotels :—

Number of off-street loading berths required	Square feet of gross floor area each berth can serve in '000s of square feet	
	Department stores, warehouses	Office buildings, hotels
1	25	100
2	42	168
3	52	208
4	59	236
5	65	260
10	78	312

Loading bays at street level for commercial vehicles to deliver or pick up goods at berths constructed inside large stores may now be seen, for example, in Chicago ; access is by archway or tunnel from the street. The provision of parking and loading facilities for long-distance coaches and for public service vehicles at terminal points is also receiving attention. The Port of New York Authority's bus terminal in New York is perhaps the best example. There are also excellent underground bus terminals in some

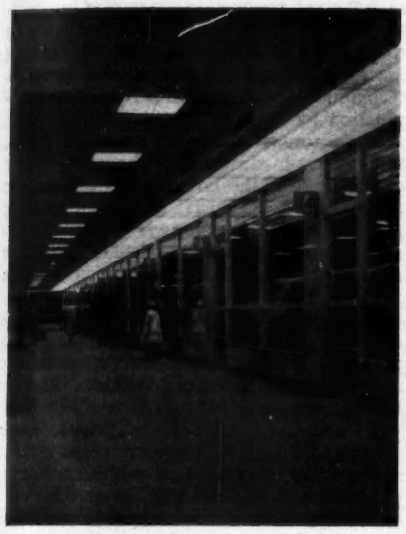

Fig. 11—Departure booths in underground bus terminal, Chicago

cities (Fig. 11). These terminals usually contain rows of shops, the rentals of which defray a considerable proportion of the cost of operating the terminal.

In suburban or residential areas, especially those that have a shopping centre, off-street parking lots are usually well designed and often most attractive. A good example is the pioneer communal shopping centre and car park in the country club district of Kansas City, Mo. The parking area may cover as much as 80 per cent of the site and as much attention is usually given to the layout of the car park as to the design of the buildings on the site.[5,6] As a result of considerable experience gained from some of these suburban parking lots, it has been found that the parking requirements can be expressed in terms of a parking index. This is the number of car spaces per 1000 square feet of gross floor area in the shopping centre. For a medium-size store or shopping centre (having a gross floor area of, say, 500,000 square feet), it is necessary to provide sufficient space to give a parking index of five to cater for the average maximum weekly demand or a parking index of about fifteen to cater for peak seasonal demand. There is one factor, however, which applies to American suburban parking lots which may not apply in other countries ; except on rare occasions, it has been found that the average American shopper will not walk more than about 400ft from the car to the shopping centre. This has an important bearing on the design of suburban parking lots, and if the required parking space cannot be provided within a range of about 400ft it is usual to provide multi-storey parking in a building near the shopping centre.

Parking on suburban lots is usually free ; the driver parks his own vehicle and locks it if he wishes, and usually there are facilities for loading goods which are purchased in the stores. Parking at 90 deg. is preferred to diagonal (60 deg.) parking on shopping centre parking lots.[6]

Many American cities are situated on the banks of a river and increasing use is now being made of the waterfront to provide car parks (Fig. 9). Notable examples may be seen in Chicago and Pittsburgh, where many thousands of cars are now parked in this way. In Pittsburgh, a main thoroughfare formerly ran along the waterfront but an overpass has been constructed so that traffic now passes above the original roadway, leaving a stretch of nearly a mile of road for parking ; access is provided by several ramps (Fig. 10).

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(*To be continued*)

Changing Nature of the Fatigue Problem

By Dr. H. J. GOUGH, F.R.S.

At the International Conference on the Fatigue of Metals sponsored by the Institution of Mechanical Engineers with the co-operation of the American Society of Mechanical Engineers, the following introductory address was presented by Dr. H. J. Gough last Monday morning. He reviews the state of knowledge in 1939 *and the general picture presented by conferences on fatigue held at Melbourne in* 1946 *and the Massachusetts Institute of Technology in* 1950.[1-4]

AS I see it, one principal object of a great conference such as this is to focus recent and current research investigation and progress in knowledge and, by discussion, arrive at balanced interpretation and evaluation. Equally important is to obtain from the engineering industries an indication of their present and probable future problems, for such indications have so often in the past afforded valuable guidance to research and inspired work which made signal contributions to technical development. For, apart from the rich and fascinating fields of investigation into basic aspects of the metallic state which it offers, the study of metal fatigue originally arose from engineering failures in service and has extended and developed side by side with engineering development, with considerable benefit to design and operation. So we might rightly expect to find a changing emphasis and pattern. In that pattern there will naturally persist, for long periods, certain threads representing problems of an abstruse or necessarily long range character, including the continuing quest for a clearer understanding of the basic mechanisms of deformation and fracture. But the main pattern will change, sometimes in a surprisingly sudden and decisive manner.

In the period between the two world wars, covering a most intense activity in this subject, a broad pattern of approach, knowledge and thought seemed to have been established. It was primarily determined, of course, by the fast and far-reaching developments of machinery in general and, particularly, in prime movers for use on land, at sea and in the air. But other patterns emerged subsequently. It may be that, when this week's papers and discussion have been critically examined in a balanced review, another change in pattern will be visible, containing emphasised threads which, formerly, were hardly discernible : possibly with new ones of sufficient intensity as to colour the whole effect.

Reflecting in this way, the thought occurred that, for this occasion, one might briefly examine the changing nature of the fatigue problem. This could have been done by a survey of major investigations, but I felt that, as a preliminary to the demands of the technical sessions, you would not wish to be blinded by slides and tables of data. Also I felt that if the pattern has in fact changed, these changes should emerge naturally, unbiased by personal selection. So I shall attempt, after presenting a sketch of the subject as obtaining in 1939 to act as a first background, to focus the general pictures presented at conferences on fatigue held in 1946 and in 1950.

The General Position at 1939

Had an international conference on fatigue been held in 1939—and one was planned—the papers* presented would have included extensive reviews covering the whole field of research. For the period from 1919 onwards was marked by an unprecedented and intense attack and general exploration of most of the problems which then appeared to be of theoretical and practical importance. A brief review is presented.

Apparently in the belief that design was based entirely on a definite fatigue limit or a lengthy endurance limit, little regard was paid to the shape of an S/N curve, although these were usually carefully determined, tests on a basis of even up to a thousand million cycles being not uncommon. Also, practically no attention was paid to the study of variable loadings involving stresses exceeding the fatigue limit. A few experiments only had been made to determine a "damage line," representing the locus of the maximum

* I have, in fact, drawn largely on a series[5] of lectures delivered at a Conference held in the U.S.A., supplemented where necessary from major publications issued in 1937/39.

endurance at an unsafe range of stress, which a material would withstand without causing a reduction in its fatigue strength below the fatigue limit value as determined, using new specimens. It was concluded that this sensitivity to damage varied widely from material to material, was affected by any previous cyclic history, and could not be correlated to any other mechanical property.

The influence of the mean stress in alternating and fluctuating cycles had been widely studied and much useful data obtained. But no general relation emerged between mean stress and safe range.

The influence of test frequency was of such practical importance that many independent, also joint, investigations had been made. At air temperatures,† no unfavourable speed effect was found at speeds up to the order of 10,000 c.p.m., and some special tests were, in fact carried out at speeds approaching 1,000,000 c.p.m. For practical purposes, the speed effect problem was regarded as solved.

Good " damping " properties may render a material suitable to meet special design requirements, such as short periods of forced vibration or occasional overloading : this property received much serious study in relation to cyclic stresses. It had been suggested that high damping capacity was related, in some way, to fatigue strength and, particularly, to low notch-sensitivity, but no such relations were established.

In the desire to reduce the laborious process of endurance testing, many and varied " short-time " methods of determining the fatigue limit had been proposed and examined : it was accepted that none of these was reliable.

As bitter experience had shown that service failures usually start at a discontinuity of form or surface, designed or accidental, extensive investigations had been made in many laboratories. While there was much evidence that the full theoretical effect of a stress concentration was often realised in a static test in which the criterion was failure of primitive elasticity, the result was very different and complicated when the fatigue limit was concerned. In general, it was found that the effective stress concentration factor, K_f, under cyclic loading was less than the theoretical factor, K_t, but the difference varied widely from material to material ; also with the size and shape of the discontinuity. Further, the notch-sensitivity under fatigue of a material was, in general, less pronounced for the higher values of K_t. But very disconcerting was the discovery of an adverse and marked specimen size effect when discontinuities were present, incidentally giving rise to disquietude over the applicability to design of results obtained from laboratory tests on small specimens. To account for this scale effect, various suggestions were put forward, including stress gradient, grain size or a limiting volume of highly stressed material, but as no critical experiments were made, no conclusion could be reached.

Directly arising from the studies of stress concentration was the skilful attention given to the devisement of improved design methods to reduce the effects of unavoidable stress raisers. Based largely on the hydrodynamical analogy of " stress flow lines," there were introduced many new and lasting features, including relieving grooves and collars, improved transition fillets with or without undercutting, and the deliberate introduction of a suitable and *additional* stress raiser to reduce the existing effect. Striking improvements in fatigue strength resulted, often with actual economy of material. In addition, new surface treatments, such as surface rolling and shot peening, had been developed and used with beneficial results, due to the introduction of compressive surface stresses.

Hitherto largely neglected, a start was made during the 1930s, in the field of combined fatigue stresses. Bending and torsional stresses in phase were studied, with and without superimposed static stresses of the same two kinds, using both plain specimens and others containing one of a few standard forms of discontinuity of section. Biaxial stress systems cannot, of course, establish any basic criterion of failure that may exist, but a first insight and some useful data were obtained.

The influence of temperature on fatigue strength had received much attention. In regard to sub-normal temperatures, it was established that, down to −40 deg. Cent., metals exhibited increasing fatigue resistance, both in the presence or absence of stress concentrations. At elevated temperatures the actual time of duration of test and a speed effect were factors to be seriously considered, in addition to the number of cycles to fracture. The general conclusion was reached for design purposes that, where both fatigue failure and undue deformation must be avoided there is, for a given material, a temperature up to which fatigue strength is of importance and above which the static " creep " properties become of greater importance. As a result, research attention tended more and more to be concentrated on the study of static creep under simple and combined stresses.

Largely stimulated by a significant increase in certain types of service failures, where an operating part was subjected to repeated stresses in a corrosive environment, an intensive attack had been made into the problem of corrosion fatigue. Once the essential nature of the problem was recognised as the conjoint action of two processes, the combined effect of which was generally very much greater than that due to either in isolation, rapid progress was made in reducing damage, principally by the substitution of more suitable materials, assisted in some cases by the use of inhibitors, surface treatments and coatings.

A useful start had also been made into the investigation of the trouble known as " frettage-corrosion " or " fretting," usually encountered at surfaces which are in intimate contact and subjected to vibration. The usual visible signs were pitting and the formation of oxide debris, while its effects varied from a mere nuisance value up to serious erosion and accelerated fatigue. Briefly, it was established that relative surface movement was an essential condition and that local metallic seizure, with some plastic deformation, was a primary factor in the action.

There are many records in service of metal components which have fractured after hundreds of millions of loadings : in some cases large visible cracks were detected for long periods. Although these components were, in general, subject to occasional overloads of unknown intensity, two problems were posed. On the theoretical side, why did such long sharp-ended cracks spread so slowly, if at all ; on the practical user side, on what basis to frame a policy of inspection and replacement. Some interesting problems of this type were fully investigated : that conducted by Illinois University into the failure of railway axles may be recalled because of its historic and present-day interest. In the field, records were obtained of the strains set up in the axles under normal and the most severe running conditions, and, after statistical analysis, the derived stress spectrum was compared with the fatigue properties as determined in the laboratory, on fairly large specimens. For the first time, within my knowledge, the effective stress concentration of fatigue cracks were determined experimentally. Batches of specimens were subjected to unsafe ranges of stress until cracks were clearly visible : the fatigue limits of these pre-cracked specimens were then found by endurance tests. The cracks did not spread unless the nominal applied stress range exceeded 50 per cent of the intrinsic fatigue limit of the material. Thus, contrary to expectations based on elastic theory, the effective stress concentration of a long sharp crack had a maximum value of two only. On the practical side the investigation resulted in a recommendation that, after a certain mileage, every axle was to be removed and critically examined for cracks.

Mention must also be made of the revival of the very early practice of the fatigue testing of full-sized production assemblies or components or of large-scale models, involving the design of large and powerful testing machines or special test rigs. It marked a recognition, in some industries, that computation by exact or approximate methods, with the results of tests on small specimens, were often inadequate to show up, under cyclic stresses, the combined effects of the presence of stress raisers and manufacturing and assembly processes, while, in regard to static proof or tests to complete failure, these not only gave no reliable indication of fatigue strength, but could be grossly misleading in that respect. So are recorded interesting accounts of such special fatigue tests, including those made on bridge assemblies and structural members, welded pressure vessels, large welded and riveted joints, oil well drill pipe, aircraft propellers, large pipes and bends, lifting gear, railway rails, railway axle and wheel assemblies and complete rear axle assemblies of motor vehicles.

Finally, some mention must be made of the specialised group of researches directed towards a better understanding of the mechanism of fatigue in relation to the crystalline and fine structure. The work accomplished in the period consisted of studies on polycrystalline aggregates, large single metallic crystals and specimens containing a few large crystals, employing the metallurgical microscope and X-ray precision methods, supplemented by stress analysis related to the crystal geometry. Observations of surface characteristics established slip primarily as a hardening process for all stress ranges, safe or unsafe ; also, essentially as a local event, confined not only to certain crystals or to regions of any particular crystal, but to portions only of a crystal plane, over the whole of which a simple and complete shearing action did not usually take place. But, apart from the general hardening, there was the more important secondary effect, whereby, under an unsafe range of stress, deformation became intensified in areas of massed slip in which the fatigue crack formed. The exact stage at which the disturbed structure could be said to contain a definite crack could not be determined by optical or any other means ; the crude process of applying a comparatively large static strain for this purpose, which had sometimes been adopted, was extremely unlikely to be critical or even informative. Similar work on single crystals and large crystal specimens confirmed that on aggregates; in addition, it established the maximum resolved shear stress law in

† Unless otherwise stated, air temperature conditions are implied throughout.

fatigue and, in proving that fatigue is a characteristic property of metals in their simplest form, indicated that any theory resting on the influence of intercrystalline boundaries, apart from an "interference" effect, must be rejected.

The extension of the investigation by the use of X-ray precision methods made possible studies of changes in the fine structure. It was quantitatively established that the distortion produced on crystal planes by slip was much greater in the slip direction than in the transverse direction, being equivalent to small rotations of portions of the structure. Under safe and unsafe ranges alike the structure broke up into a disoriented mosaic, with the production of crystallites of completely random orientation and a limiting size of 10^{-4} or 10^{-5}cm. But these effects occurred also under static straining and were accepted as the consequences of plastic deformation and the cause of strain hardening; they were not discriminative in regard to fatigue failure. Further 5A, 5B static and fatigue tests were therefore made on severely cold-worked metal, thus initially in an extreme condition of fragmentation. They yielded quantitative data indicating that the fracture stage was reached, irrespective of the type of loading, when internal strains and distortions of such intensity were induced in the crystallites as likely to overcome the forces of atomic cohesion. In a static test to failure relatively large volumes of metal arrive simultaneously at the fracture condition; under fatigue that same condition is reached progressively and extremely locally. A much deeper insight was thus obtained into the essential differences between deformation and fracture conditions in general and between static and fatigue failure in particular.

With that extremely condensed review as a background for the pattern of 1939, let us pass over the eventful years of war and glance at the subjects of discussion in 1946.

The Melbourne Conference of 1946

In December, 1946, the University of Melbourne staged a conference on the fatigue of metals, to which thirty papers were contributed by authors from Australia, Great Britain and the United States. It was indeed opportune, a welcome return to the free public interchange of thought and experience that had been suspended during the war years. During that period, research effort had naturally been concentrated on new problems of wartime developments and difficulties attending exceptionally severe user conditions. The closely-packed 500-page *Proceedings*[6] thus also contain much of interest to the historian and designer, but I must confine myself to the attempt to indicate the trend of investigation and thought disclosed.

Following a general introduction[7] to the subject and a review note[8] on various theories of fatigue, one series of papers,[9, 10, 11] presented descriptive surveys of analytical, metallographic and test methods of investigation, with new data. An authoritative account[12] of the electro-chemistry of corrosion-fatigue was presented; also a review[13] of the nature and effects of residual stresses on fatigue strength, emphasising the beneficial influence of compressive surface stresses. The practice of shot peening[14] to improve fatigue strength or life had been considerably extended during the war, while the need for accurate information regarding the varying loadings imposed in service, often in regions inaccessible during operation, had led to marked development and use of various forms of recording strain gauges.[15]

Valuable and detailed accounts were given of fatigue failures in service, one series of papers[16, 17, 18] covering railway experience. Apart from manufacturing defects, the primary causes were stress concentration effects and surface defects, accelerated in some cases by corrosion and fretting; the press-fit had presented special and difficult problems. Experience in the heavy machine industry[19] traced failures to the same primary causes. Much study[20] had been given to the development and critical use of non-destructive methods of crack detection: it was concluded that, for magnetic materials, the magnetic particle method was the most satisfactory, while for non-magnetic materials the fluorescent penetrant method was favoured, ultrasonic methods requiring further development. The practical recommendation made was that, as no method exists for determining when fatigue is in operation, a part should be immediately replaced or repaired when a crack is detected in service.

Other papers dealt with specialised service applications. Fatigue failures in bearings of internal combustion engines had been largely overcome by alterations in design and the development of improved bearing alloys.[21] Over 60 per cent of the breakages of aerial telephone lines had been traced to fatigue, due to vibration resulting from wind eddies: good results had been obtained from improved joints, ties and terminations having specified damping characteristics.[22, 23] An interesting paper[24] presented a study of the fatigue problems encountered in the gas turbine aero engine, still in the early stages of development and involving complex combinations of static and superimposed cyclic stresses of high frequency at operating temperatures in excess of 600 deg. Cent. in a corrosive atmosphere. Papers of considerable practical interest dealt with a proposed basis of design for combined stresses[25] and the fatigue failure of bolts, studs and nuts, with improved forms of design.[26]

Much attention was devoted to the general subject of stress concentration effects: to the available means of estimating and comparing the theoretical and practical effects by exact and approximate analytical methods,[27] by photo-elasticity,[28] by direct and indirect methods of strain measurement, by plaster and rubber models and by relaxation methods. But there remained the puzzling anomalies of the variation of notch sensitivity values, of its dependence on the numerical value of the theoretical factor, K_t, and of the disturbing size effect.

A group of papers concerned aircraft problems. Two[30, 31] of these primarily related to the properties and failure of aircraft materials of construction: a third[32] to the specialised subject of the fatigue of welded steel tubing. But there was a paper,[33] one of the shortest in actual length but of such importance as to be epochal in fatigue literature. In regard to the authoritative knowledge and experience of the author, I quote from his paper: "It happens that during the recent war I have been concerned with others in the measurement of the loads arising on aircraft structures during military operations. Such measurements have now been made on hundreds of aeroplanes of different types during thousands of flying hours, and the loading statistics thus gathered give a fair picture of the nature of the varying loads arising on aircraft structures. It is now possible to say that loads of the order of three-quarters of the ultimate strength of an aeroplane wing arise about once in the aeroplane's life, whereas loads equal to one-half of the ultimate strength occur roughly 500 times. These and similar data provide, probably for the first time in structural engineering, an experimental statistical background for the discussion of repeated loads." It was then pointed out that the practice of considering structure strength in terms of static loads or repeated loads of constant amplitude might be misleading, especially if these were based on properties of materials determined by laboratory tests on small specimens rather than on the structures themselves or on structural components. New types of investigation were required into random loading effects, including different sequences of the same loading. Joints and other regions of stress concentration were most likely sources of initiation of failure while, in a redundant structure, partial failure of one part may transfer to another an unduly high repeated loading which it could not survive. Attention was drawn to the necessity for fatigue tests on complete structures. Finally, the suggestion was made that, taking rigid maintenance, inspection, repair and ordinary replacement for granted, a considered and definite life should be assigned to an aircraft structure.

The paper I have been referring to came from this country: another paper,[34] from the U.S.A., supported and endorsed the same basic facts and views. So the importance of fatigue in relation to the strength and safety of aircraft structures was publicly and authoritatively recognised. Since then, much information has been published in official and other papers, showing that the previous basis of design, development and testing has been profoundly revised by taking into account the variable aerodynamic loadings which occur in flight, while much further attention has been paid to their measurement. A further direct result was the immediate stimulation given to research in the two fields—to which later reference will be made—of "cumulative damage" and "statistical methods," hitherto largely neglected and to which, as always, the universities and other non-specialist research organisations were to make such important contributions.

So much for the pattern presented by the Melbourne Conference.

The 1950 Conference on Fatigue and Fracture

In June, 1950, a special conference[37] on the fatigue and fracture of metals was held at the Massachusetts Institute of Technology with the expressed object of focusing knowledge and experience of this field by papers contributed by specialists in the various aspects: fourteen important papers were presented and discussed. Of that number, four[38, 39, 40, 41] dealt with types of brittle fracture not directly attributable to fatigue. Of the remaining eleven papers on fatigue, some constituted valuable general reviews which, for the present purpose and to avoid repetition of what has been already substantially referred to, it must be sufficient to denote by subject only, pointing out, however, that these were fields in which active interest had been maintained and steady progress accomplished. These subjects were: internal stress,[42] selection of material by the designer with special reference to light alloys,[43] transition temperatures,[44] influence of metallurgical structure,[45] and techniques of physical metallurgy in the study of fatigue.[46]

A paper[47] dealing with the field of high temperatures showed that, since before the war, little attention had been given in the U.S.A. to fatigue testing at elevated temperatures.

Major interest and importance had clearly been attached to four subjects, of which

stress concentration effects was one. One paper[48] discussed that subject in relation to machinery in general, where stress raisers continued to be the predominant cause of service failures: much experimental data was discussed in relation to theoretical and effective stress concentration factors and to notch sensitivity. An interesting and new feature presented was a three-dimensional model for fatigue under direct stress in terms of the tensile ultimate strength, which exhibited relationships between stress range, mean stress of cycle and cycles to failure, for both plain and notched specimens.

The other three major subjects were almost entirely of post-war development.

A comprehensive paper on the fatigue problem in aircraft structures described the revolution in thought and outlook that had taken place in the United States, with its effects on design and research and development programmes. The reasons for the emergence and recognition of the fatigue aspect were, of course, basically similar to those previously discussed at Melbourne. But in the meantime the problem had intensified by the continuing trend of development in engine power, aircraft size and service requirements. Increased flight speeds meant, in a given flying time, an increase in the number of gusts encountered and higher gust load for a given gust velocity. Developments in materials had produced higher static strengths, but often without proportionate increases in fatigue strengths. The serious difficulties placed on the structural designer in this exceptionally difficult branch of engineering were discussed, with his new objective of designing for a limited life, with only a small probability of failure in selected and non-vital components, while still endeavouring to maintain a satisfactory strength-weight ratio. This involved the determination of repeated service loads and their statistical treatment, together with a knowledge of the resistance of the structure to these loads, taking into account the response of the structure.

Lastly, to brief mention of the subjects of the statistical treatment of fatigue data and the problem of cumulative damage.

However many specimens are tested in the usual type of fatigue test, there is no exact answer to the question, or its converse, as to the number of cycles N which a specimen or a component or an assembly will endure before failure even under a constant stress amplitude S: this is due, of course, to the characteristic "scatter" of results. The probability of failure P has to be introduced and the ordinary approximately determined S/N curve has, ideally, to be supplemented by a family of P-S-N curves. This involves extrapolation, with the derivation of distribution functions of S or of N to make possible such extrapolation. This particular statistical aspect of fatigue was fully discussed in a paper by Weibull,[50] one of the earliest European workers in this field. I may perhaps usefully recall that the first[52] of an extensive series of papers by Freudenthal and his associates on the application of statistical methods to fatigue was published in 1946; he did not contribute to the 1950 Conference, but mention of the two dates assists to show in what a very definite and short period this subject came into prominence.

Lastly, to a notable paper[51] on "Cumulative damage," which showed the extensive, if long-deferred, attention then being given to that aspect of fatigue. The term had become generally adopted to express the idea that, during any stress cycle, a certain amount of damage—positive, zero or negative—was suffered, which was cumulative, total damage being represented by complete fracture. The general problem was to assess the damage suffered from a cyclic history of various stress amplitudes and, if possible, to express this in terms of the remaining capacity to resist further fatigue action. Apart altogether from the practical difficulties of dealing with numbers of combinations of S and N is the absence of basic knowledge on which to form a quantitative estimate of total physical damage and capacity, or of the actual rate at which damage is inflicted even in the simplest case of a straight run to fracture under a constant stress range; further, there is no justification for any assumption that the damage cycle ratio rates are similar for different values of stress range, or that the total result is independent of the sequence in which the stresses are applied.

In spite of these difficulties, some method, however approximate, would be helpful in estimating probable life until the facts are established. The hypothesis put forward by Miner[53] in 1945 assumed a linear rate of damage and a limiting value of unity at fracture for the arithmetical sum of cycle ratios $\left(\Sigma\frac{n}{N}=1\right)$. Comparison with experimental data showed that with occasional approaches to unity value, extremely wide variations of under- and over-estimation were found. Rates of damage other than linear were also examined, but it was realised how much investigation remained for urgent attention in this field.

Conclusion

This concludes my sketch review for which I claim your indulgence in having brought so many "coals to Newcastle." I can only trust that, by having taken three significant accounting points, I have been successful in the attempt to convey some indication of the broad development of the subject in recent years. To remove a possible misunderstanding I have not overlooked the number of outstanding papers which have been published since 1950. But I found, as the present papers began to come in, that practically all very recent work has naturally been reviewed in those papers on which I have been very careful not to trespass in any way.

I am quite sure that this Conference of 1956 will come to be regarded as an important focal point of knowledge of our subject. The broad picture it will finally present, when placed side by side with those of 1939, 1946 and 1950, will certainly settle whether I had any justification in my theme of "the changing nature of the fatigue problem."

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Expenditure on Research and Development

Surveys have been carried out by the Department of Scientific and Industrial Research to obtain an up-to-date estimate of the investment in research and technical development in this country. Although these surveys have not yet been completed preliminary estimates were presented in a paper before the British Association on September 4th. A note from the D.S.I.R. points out that these estimates are subject to relatively large margins of error and that they may have to be revised when the surveys are completed. They are, however, believed to be correct as to the order of the amounts expended. It is estimated that some £325 million was spent on research and development in this country during the financial year April, 1955, to March, 1956; at the same time, it is pointed out, the error in this figure may be as high as £80,000,000. This error is shown as a plus and minus figure with each total estimate. Of the estimated total £185 million (plus or minus £40,000,000) was spent in private industry—mostly by aircraft, electrical engineering and chemical firms, who accounted for three-quarters of the total. Expenditure in Government laboratories accounted for £122 million (plus or minus £35,000,000), and of this sum the supply and Service departments spent over £74,000,000, whilst atomic energy research accounted for an estimated £30,000,000 (plus or minus £25,000,000). For research and development work during the year, the D.S.I.R. made grants totalling £2,200,000 to associations, students and universities; the Ministry of Supply paid some £109·2 million to industry and universities, and the Admiralty placed research and development contracts valued at £7,800,000.

S.B.A.C. Flying Display and Exhibition

No. II—(*Concluded from page 335, September 7th*)

THE Flying Display and Exhibition of the Society of British Aircraft Constructors gave an opportunity to inspect one new aeroplane, the Vickers-Supermarine type "544," built to naval specification N.113, and illustrated in Fig. 1 (*ante*). The aircraft seen at Farnborough differed from that illustrated last week, principally in having a rounded nose instead of a pointed one with a probe mounted on it. The air intakes have thin, but rounded, tips, while below the fuselage a stocky nose leg is extended by a pair of rams. From the rear, it can be seen that the two R.R. "Avon" engines exhaust slightly outwards, and the resultant broadening of the fuselage towards the tail pipes gives the waisted effect familiar since the "area rule" became established. The fine and fair lines of the fuselage are broken abruptly aft of the jet tail-pipe fairings; a long and robust divided arrester hook demands a large V-shaped cut-out in the underside, and within this vee the retractable tail skid is mounted. Behind the skid is a fairing which, while improving the profile of the aircraft, ends in the hook itself.

The tail has a heavily swept fin and rudder and a similarly swept moving tailplane with a cone mounted on it. The rear part of this cone can contain a parachute for landing or spin recovery. The sheer commencement of the fin fairing is an air intake. Dive brakes lie flush with the fuselage skin.

It will be recalled that a forerunner of this aircraft, the Supermarine "508," had a butterfly tail with ruddevators, which was not a feature of the intervening "525." It can now be seen with more clarity why the original attractive design, which allowed the tail surfaces to spring straight from the fuselage without lying close to the turbine efflux streams, was abandoned. The transonic aircraft now very generally uses the tailplane as a whole for longitudinal control, at least for the high speeds at which sharp changes of turn may occur, but directional stability is still provided by a fixed fin.

The wings of the "N.113" are, apparently, skinned with the conventional sheet metal, but the surface finish is excellent and joints cannot be discerned; this fine finish extends also to details such as the navigation lights. The ailerons are exceedingly close-fitting, and the aircraft was apparently not one of those with provision for flap-blowing. The leading edge is hinged at the lower surface of the wing along its full length, except the extreme tip. This requires the division into two of the very deep fence that now emphasises the "saw tooth" of the leading edge.

It may here be observed that the increased tip chords appearing on hitherto plain swept and delta wings, due to the fact that, at the tips as well as at the roots, sweep is not a sufficient substitute for low thickness-chord ratios in raising the critical Mach number, is regarded by Handley Page as vindicating the crescent plan form, in which the sweep and the thickness vary in opposition along the span (see page 56, January 9, 1953).

A curious feature of an airframe clearly designed for supersonic flight is a venturi tube mounted on a long mast below the starboard wing. This may be employed for a sensitive pressure instrument used in carrier approaches, but appears to be so close to the outboard jettisonable fuel tank as to be effected by its presence. The aircraft is, of course, a large one, but it would seem that its configuration, with a swept wing of conservative thickness and the minimum of volume and surface area devoted to the power plant, should allow a high maximum speed—comparable foreign machines are being built to exceed 1000 m.p.h.—without sacrificing the tank capacity needed for Fleet use. The provision of two engines may also be an advantage if, say in the defensive fighter role, it is required to cruise at an uneconomically low altitude when one only could be used.

Fig. 10—A Hawker "Hunter" demonstrating reverse thrust; smoke generated in the turbine exhaust is being expelled through cascades in the rectangular panels below the tail

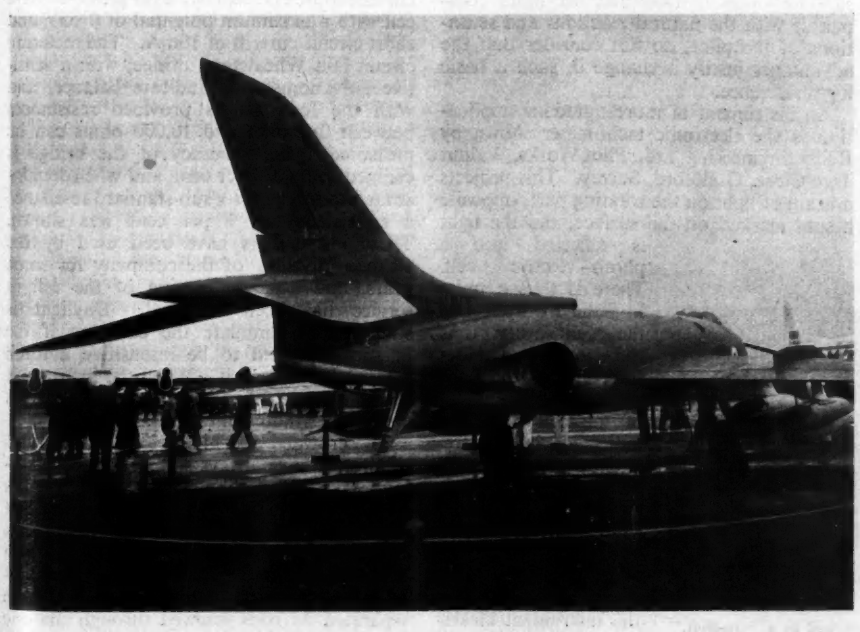


Fig. 9—The Supermarine "N.113," showing the anhedral slab tailplane now used on the first prototype

A new engine could also be seen on the static park and in the air, the Bristol "Orion" "supercharged" turbo-prop installed in the port outer nacelle of a "Britannia." The engine fits into the nacelle with, seemingly, space to spare, but, as might be expected considering that the aerodynamic components are large enough for an engine twice as powerful as the "Proteus," the exhaust duct running along the top of the nacelle is greatly enlarged. The two small air intakes low in the cowling in Fig. 11 lead to the oil coolers, the air flow being regulated by the flap seen at the exit.

On Saturday last, the weather permitted a more ambitious flying display. Two Fairey "Delta II" aircraft took off and climbed to 31,000ft and 32,000ft. They converged on Farnborough from Newbury and Gatwick, using their after-burners to attain a closing speed of about 2½ Mach. The aircraft could not be seen from the ground, either because condensation trails were not forming or because they were hidden by broken cloud, but this very fast

Fig. 11—The first Bristol "Orion" power unit running under test conditions

pass made itself evident with a single well-defined percussion as the shock fronts reached the aerodrome. The aircraft were airborne for about twenty and twenty-one minutes, and did a good deal of ground running, but reheat was probably used only for short periods. The aerobatic displays were favoured by the higher ceiling, and the Hawker "Hunter" two-seater enhanced its demonstration by discharging red smoke from the wing tips during a sustained roll. Another performance that attracted great attention was the "avalanche" performed by the Auster "Aiglet" trainer. This has been described as a flick roll performed at the top of a loop, i.e. from the inverted through the upright to the inverted attitude. The essential feature of the manœuvre is that it is performed in the reduced g field obtaining at the top of a curtate cycloidal loop, so that the stalling speed of the machine is reduced very greatly and it appears to rotate rather about a point than a line. The thrust-reversing "Hunter," seen in Fig. 10, touched down extremely early on the runway and ran past the spectators shuddering under reverse thrust.

Static Exhibition

Again this year, Farnborough greeted a jet engine of greater thrust than any previously attained by a British engine. The Bristol "Olympus" B.Ol.6 develops 16,000 lb without reheat, an increase of 33⅓ per cent on the "Olympus" 102, which holds the altitude record for aeroplanes. This is, of course, a two-spool engine, and the high pressure ratios possible are expected to yield the theoretical benefits of low fuel consumption and maintenance of power to extreme altitudes. Another new engine was the de Havilland "Gyron Junior," for which no performance figures have been officially released. It is basically similar to, but smaller than, the "Gyron," relying on ram compression to supplement a single compressor, and calling for a rocket motor at the relatively low indicated air speeds appropriate to high altitudes. In appearance, it is rendered more pleasing by the neat plumbing of a Dowty fuel system, while the construction of the central "spinner" suggests that it is started by a compressed air motor.

It can now be seen that, although the inlet guide vanes of the D.H. "Gyron" have circular platforms at tip and root, the incidence cannot be varied, except possibly as a servicing operation.

An attitude indicator with a new presentation, which is regarded by Kelvin and Hughes, Ltd., as the herald of future information displays designed to meet the pilot's needs rather than giving the data that can be most conveniently measured, made its first public appearance in the static display. It is driven by servo motors controlled from a master stabilised gyroscope unit, and shows movements of the aircraft about pitch and roll axes. A "roller blind" runs to and fro on the front of a rotating table; one half of the tape, lengthwise, is black and the other half is white, and when flying straight and level the two halves join in a horizontal line across the middle of the circular dial. Rolling of the aircraft causes the turntable to rotate the "blind," there being unlimited travel in both directions. Pitching causes the tape to be reeled up or down the turntable; considering a loop, the black part of the band will move off the bottom of the screen, and when the aircraft is vertical a mark indicating the zenith will be in the centre of the dial. In space, the horizon has, of course, no direction from the zenith, but the blind is not continuous and the vertical mark indicates the centre line of the tape. Because the tape has only one horizon, it is necessary for the turntable to rotate 180 degrees as the aircraft passes through the vertical. The instrument is furnished with internal lighting, and circles on the concave dial assist estimation of attitude. The display moves in the opposite direction to the aircraft. The makers, while accepting that the "outside in" presentation may be more compatible with the natural reactions and sensations of the pilot, do not consider that the advantages justify a change in such a basic flight reference.

An instrument of more mundane application is the electronic tachometer shown by Reilly Engineering, Ltd., Pilot Works, Walnut Tree Close, Guildford, Surrey. This projects a beam of light on the rotating part, opposite a spot marked on the surface, and the light is reflected into a photo-electric cell. There is thus a pulse in the output of the cell every time the spot passes under the light, and the fundamental frequency of the cell output is indicated by a frequency meter calibrated in revolutions per minute. The light source and cell are combined in a small probe which can be mounted in even confined spaces: the instrument clearly cannot affect the speed of even the lightest drive. Two ranges are provided, 1000 to 20,000 and 10,000 to 200,000; the ranges can be extended downward by putting more than one spot on the shaft. It can be seen that the instrument is applicable to other repetitive phemonena than revolutions. An accuracy of 2 per cent f.s.d. is attainable, so that a crystal frequency source is not considered justified, the appeal of the instrument being its simplicity and low cost.

An example of an instrument adapted to a specialised purpose was the photo-electric safety ohm-meter displayed by the Fairey Aviation Company, Ltd., Heston, Middlesex. This is intended for testing electric circuits in which explosive igniters are incorporated, and to which only minute currents can safely be applied. The ohm-meter shown is intrinsically safe in this application, since the current source is a barrier layer photo-electric cell with a maximum potential of 0·55V and short circuit current of 10mA. The metering circuit is a Wheatstone bridge, with a sensitive galvanometer to indicate balance, and with the four ranges provided resistances between 0·1 ohm and 10,000 ohms can be measured. The accuracy of the bridge is claimed to be 0·3 per cent, and when demonstrated to us against a sub-standard resistance a consistency of 1 per cent was shown. These instruments have been used by the weapon division of the company for some years, and no deterioration of the cell in service has been observed. Daylight is sufficient to stimulate the cell, but if the balance is found to be insensitive a torch can be shone upon it. When the instrument is not in use, the lid enclosing the leads covers the window of the cell.

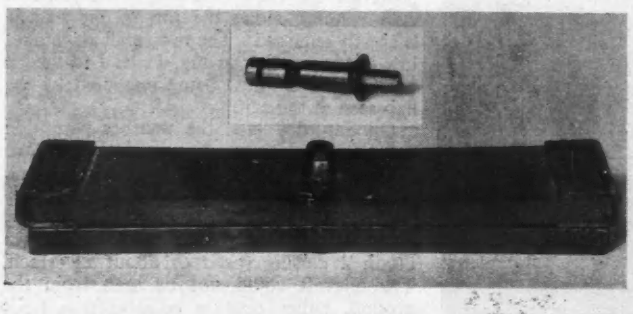


Fig. 12—This test specimen shows the positive clamp exercised by a "Jo-Bolt," inset, and the small size of the head on the blind side

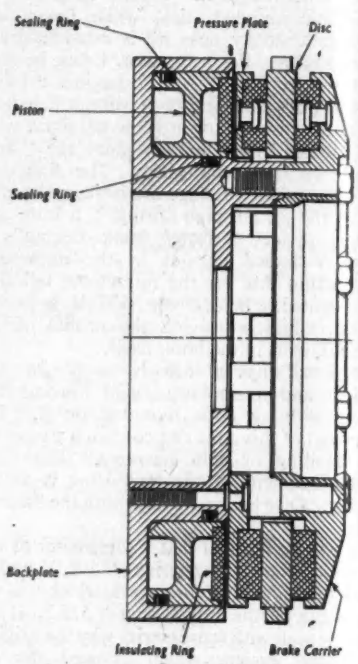


Fig. 13—Disc brake for light aircraft, with annular piston

The crowded and highly loaded structures of aircraft have always supported a flourishing family of fastening devices, and new ones appeared this year. An unusual example of detail design in this respect was visible in a section of 6 per cent thick wing displayed on the Folland stand, wherein spanwise stiffeners on upper and lower surfaces were separated by rods screwed through the one but merely located in a hole in the other,

and in both cases finished flush with the skin after fitting. It is claimed that the problems of corrosion attack on explosive rivets have been overcome in the case of Du Pont rivets, and for setting these rivets Desoutter Brothers Ltd. The Hyde, Hendon, N.W.9, has evolved a tool which, resting against the surrounding plate on two rubber pads, heats the rivet by rotating at many thousand revolutions per minute a "Tufnol" pad spring-loaded against the rivet head. The tool is driven by a small air motor: while an electric soldering iron may be necessary for inaccessible rivets, where one side of the job can be easily reached this tool avoids the use of wandering electric

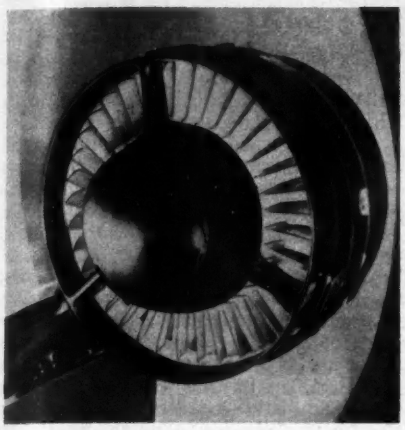


Fig. 14—Intake side of ram air turbine to provide hydraulic power in case of engine failure

leads and the risk of shocks or burns. It also is claimed to have a longer service life than a resistance heating element. Another blind fastener is the "Jo-Bolt" of Aviation Developments, Ltd., Welwyn Garden City, Herts, illustrated in Fig. 12. In this device the shear loads are taken by a high tensile steel nut, while a bolt of the same material is used to draw a malleable stainless steel sleeve up the taper on the shank of the nut and compress it against the work. The bolt, the tail of which is flattened to fit into the driving tool, breaks off when the fastener is placed, so that correct tensioning is not at the discretion of the operator. Hand and pneumatic tools are available for placing, the former for awkward locations: the head of the nut is recessed in the case of countersunk "Jo-Bolts" and hexagonal for others, so that it cannot turn as the bolt is tightened. The assembly is locked by the deformation of the stainless sleeve, and is claimed to have superior vibration resistance to a bolt and locknut. To remove it, the head of the nut is drilled in two stages to just under the nominal size, using a special drill guide, and the shank knocked out. A series of tests on $\frac{3}{16}$in bolts securing two $\frac{1}{4}$in mild steel plates showed that tensions in excess of 1200 lb were needed to loosen the plates, failure occurring at 2150 lb or above, and shear failure took place at over 2650 lb, 2730 lb on average of six tests. The fasteners are also available in $\frac{1}{4}$in and $\frac{5}{16}$in sizes and the grip ranges vary from 0·094 to 0·156in up to about 1in, the longer sizes not being available from stock. That the correct grip range has been selected can be checked after placing by measuring the depth of the broken end of the bolt.

The Palmer Tyre Company, Ltd., Herga House, Vincent Square, S.W.1, has now developed its annular piston brake, which was in use on some of the helicopters in the flying display, to offer the advantage of low-pressure operation to users of aircraft of less than 3750 lb weight. The restricted air cooling of this design renders it unsuitable for applications involving great kinetic energy. As can be seen in Fig. 13, the disc is driven by its periphery, as is customary on Palmer brakes, and is clamped between friction linings on a fixed carrier and a moving plate: torque is taken out of the pressure plate by a set of keyways in the back-plate. The pressure plate is insulated from the piston by a ring of non-metallic brake lining material. Adjustment is not normally provided on these brakes, since the gravity head of oil keeps the linings in light contact with the disc, but in case this affects the take-off performance of light aircraft provision has been made, as can be seen, to fit return springs and threaded adjusters. An annular piston brake was also shown by the Goodyear Tyre and Rubber Company, Ltd., but in this case with a set of several small circular friction pads. This company is supplying for use on the Douglas D.C.7C a brake referred to as "Trimetallic," eight rotating steel discs being surfaced with a sinter of a special iron mix. The static discs are of a different steel with which the sintered iron is not compatible, so that there is no possibility of fusion between the discs. The discs being only $\frac{3}{16}$in thick, a smaller brake than normal can exert the same torque, and the increased proportion of metal gives a relatively larger heat sink. This brake is installed in a forged bowl wheel claimed to be lighter, with a longer fatigue life, than a cast wheel, and needing no impregnation when used with tubeless tyres. Another disc brake on this stand reduced the wheel to a mere rim running round the brake on two very large diameter taper roller bearings, thus giving an even larger energy capacity within a chosen tyre. The Goodyear anti-

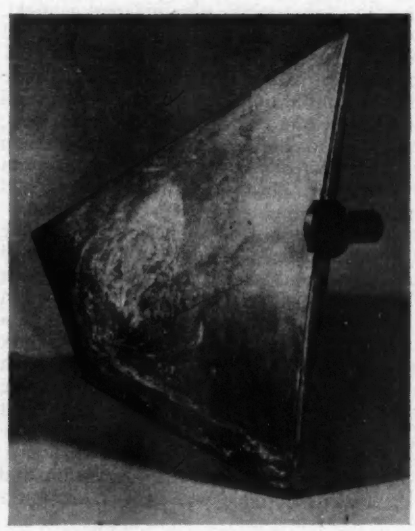


Fig. 15—This light alloy guided missile fin is bonded to the steel root fitting by the "Alfin" process

skid unit has been modified and now employs a mechanical, inertia, deceleration detector to actuate an electrical signalling device: this controls the brakes by means of solenoid valves, and can easily be arranged to affect two or more brakes together in order to maintain straight line braking. The detector fits within the wheel axle.

Although windmills continuously running during flight were discarded many years ago in favour of engine-driven auxiliaries, the high energy demands of the radio, braking, control and other systems of the modern aircraft call for excessively heavy or expensive energy accumulators to meet the emergency of engine failure. To counter this difficulty, ram air turbines driving hydraulic pumps or electric generators have been developed. An example is illustrated in Fig. 14, built by

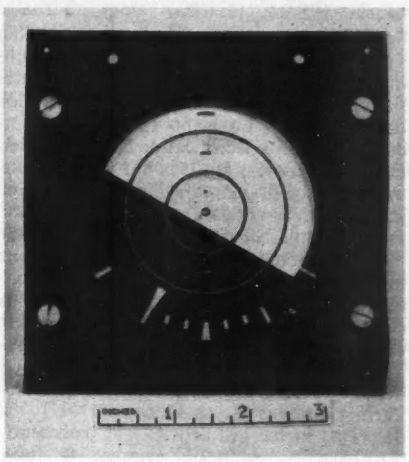


Fig. 16—The "roller blind" attitude indicator, showing a slight climb markedly left wing low

the Plessey Company, Ltd., Ilford, Essex, to deliver $3\frac{1}{2}$ hydraulic h.p. at 150 knots indicated, rising to $8\frac{1}{2}$ h.p. at 210 knots. The turbine, which has a single set of nozzles and buckets, can be operated at flight speeds up to Mach unity, a rotor maximum speed control being built in. The unit can either be arranged to swing out into the airstream in emergency conditions, or be located permanently in the airframe with a suitable duct to supply air. Similar in conception were the hydraulic and fuel pumps for ram jets on the Bristol stand; both were driven by air turbines, the former considerably larger than the latter, and having a hydraulic control gear operating butterfly dump valves on the air intake side of the turbine.

Another interesting detail of missile engine engineering was displayed by Wellworthy, Ltd., and is shown in Fig. 15. The aerofoils are the control surfaces of a guided weapon, and the inertia loads and flutter forces involved were sufficient to loosen a riveted joint between the light alloy fin and the steel spar—presumably during a single flight. The "Alfin" bonding process, normally used where good heat transfer properties are required, as between brake drums or cylinder liners and their cooling fins, was applied to the plain end of the steel shaft, and the fin was die cast upon it. The mechanical strength of the bond is described as satisfactory, although the stresses and temperatures involved cannot be disclosed.

PROMOTION OF EXPORTS.—With a view to making a useful contribution to the expansion of export trade the Advertising Association has issued a special edition of its journal entitled *A Practical Guide to the Promotion of Exports*. It has been compiled under the editorship of Mr. Roger Falk, and contains articles by five contributors. The articles are: "Overseas Market Research," by Mr. Martin Maddan; "Overseas Selling," by Mr. A. E. V. Houchen; "Overseas Advertising," by Mr. H. Deschampsneufs; "Colour, Pack and Presentation," by Mr. E. Biggs, and "Services that Help the Exporter," by Mr. G. P. Vigart.

Further French Locomotive Experiences

By EDWARD H. LIVESAY

(*Continued from page 324, September 7th*)

No. VI—FOUR-CYLINDER COMPOUND TANK ENGINES, PARIS AREA; No. 32-U1, FOUR-CYLINDER COMPOUND EXPRESS ENGINE, PARIS/DOUAI.—PART I

THE great variety of industrial activities carried on in north-eastern France results in correspondingly heavy freight traffic over the lines radiating from Paris in the direction of the Belgian, Luxembourg and Saar borders. Extensive electrification has been undertaken in this area, but it is not yet complete, many of the trains carrying ore, coal and manufactured goods from the mines and factories, still being worked by steam locomotives. Some of these engines are of an interesting and unusual type, and arrangements were made by Monsieur Segaud, of the Department of Design, S.N.C.F., to enable me to spend a few days with them. The tour began at Valenciennes, to which depot Monsieur Fillon and I had come from Paris, riding as far as Douai on "U1," as described in the last article, and thence in a three-coach "Autorail," similar to those running over many branch lines in France on which traffic does not justify full-length trains. Here, after a farewell lunch with Monsieur Fillon, I was introduced to Monsieur Roger Forray, chief of the depot at Mohon, Ardennes, who was to come with me throughout the projected tour, to act as guide, expositor and interpreter, a role for which he has well qualified, he not only speaking admirable English, but being thoroughly familiar with the terrain and the equipment used by the Eastern Region. I cannot be sufficiently grateful to Monsieur Segaud for the smooth working of the complicated schedule arranged for me; there was never a hitch anywhere, and Monsieur Forray proved to be an admirable courier.

We left Valenciennes on a 2-10-0, three-cylinder, simple freight engine of French construction, No. 150/138, at the head of a 1850-ton train; some of the chief dimensions of this machine are as follows:

Cylinders, three	22in by 26in
Driving wheels, dia.	4ft 7in
Heating surface, fire side	2192 sq. ft
Superheater, elements	32
Boiler, dia.	59in
Steam pressure	203 lb
Firebox, long, narrow, steel, with arch tubes. Mechanical stoker.	
Grate (rocking), area	35·3 sq. ft
Two injectors, no feed-water heater.	
Engine, weight	97 tons.

The train was made up of the usual 30-ton gross, four-wheeled, air-braked wagons; it got away at 12.32 p.m., at once beginning a very heavy ascent, much of the gradient 1 in 100, that extended for upwards of 20 miles nearly to Aulnoye (Fig. 1). It was decidedly heavy going, but the engine steamed freely, the pressure remaining well up, and nothing showed signs of stress; not even the fireman, thanks to a mechanical stoker. The speed was generally about 12 m.p.h. to 15 m.p.h. on the almost constant incline, up which considerable stretches of rails were welded, in 800 metre lengths. Where the train had to be checked, for signals or on occasional short downward dips, it was pleasant to note how easily the 1850-ton load was controlled by the Westinghouse brake, and impossible to avoid comparsion with the very dissimilar state of things in Britain, where unbraked, loose-coupled trains still trundle along at leisurely gait, thereby considerably reducing the carrying capacity of the lines they cumber. The route this train was running over was hard enough on this powerful 2-10-0 engine with 1850-tons trailing, but it would have been impossible of negotiation with unbraked wagon stock.

Beyond Aulnoye the route became somewhat less severe, the gradients more fluctuating, though the ruling figures were much the same; the engine did have breathing spells. Nevertheless, the going would remain hard for 60 miles to the peak near Liart; I should have been sorry for the chauffeur if it had been a hand-fired engine. Only once did it momentarily loose footing, on a nasty curving piece of 1 in 100 near Avesnes, for which no blame could be attached—the load was heavy. I commented on the scarcity of passing traffic, but Monsieur Forray explained that things were different at night, when most of the freight trains moved. I also commented diffidently on the rather attenuated cab, which did not give quite enough protection against the bitter wind that swirled into it. Monsieur Forray agreed, and tried to comfort me with the information that tomorrow's engine would be better in this respect. But this was to-day, and we had a long way to go yet!

Electrification of the Valenciennes-Thionville line, over which we were running, was well advanced, and one or two test trains went by; the 25 c/s single phase system was in operation here, and the first sub-station noticed at Fourmies. The Hirson stop took place at 3.38, so the 50-mile stretch from Valenciennes had been covered at an average of 16 m.p.h., quite creditable when the weight of the train and the severity of the route are considered. Here the economy of the engine, crew and super-cargo received attention, and the entente cordiale was toasted in appropriate vintage, a French custom of which I thoroughly approve, and in addition, the fact that the enginemen—whose names I regret not noting—were not excluded from the ceremony. This was a freight run, and everything was correspondingly democratic and informal! Nobody was below the salt.

The profile shows that from Hirson onward the engine had a less difficult task for 20 miles or so, the last long pull up to Liart being only 1 in 130 instead of the prevailing 1 in 100, but in any case, the whole distance from Valenciennes had been heavy going. At Liart, on the ridge overtopping Charleville, a wireless mast was noticed, erected, I believe, for experiments in radio communication between dispatchers and train crews. From this point, with all the hard work done, the track trended downward into Charleville, reached at 5.40, where we transferred to a car, and were driven, via Mohon, Monsieur Forray's depot, to Sedan's Hotel de Paris, the haven to which I had been looking forward for some time, as physically I had been none too happy all day. A chill, caught at Marseilles a few days before, was reasserting itself, and the engine's somewhat skimpy cab had encouraged it. The weather had been cold and windy, quite unlike my anticipations of France in September. Driving over the open, rolling, almost treeless country, one could not help thinking what an ideal site it must have been for the battle of Sedan, as from many high points the whole country lay spread out like a panorama, and this was where it was fought. One could picture a general on one of these elevations, following, through binoculars, with his staff around him, the progress of the action.

The next morning, while driving to the locomotive depot at Lumes, some 10 miles from Sedan, the road running alongside the Meuse, Monsieur Forray pointed out the place where the invading German armies had forded the placid shallow river both in 1870 and 1914—and I daresay in 1940 also, but Nemesis obviously caught up with them that time—I should be riding a German "reparations" locomotive all this happy day. *Et je n'ai rien à y dire*—either the reparations or the engine! But we anticipate. At the shed, it turned out to be another three-cylinder 2–10–0 (Fig. 2), roughly similar in design to its French counterpart of yesterday, with the following dimensions:—

Cylinders, three, dia.		22in
,, stroke		26·4in
Valves, dia.		12in
,, maximum travel,	outside cylinders	7·3in
,, ,, ,,	inside cylinders	6·5in
,, maximum cut-off	outside cylinders	80·5 per cent
,, ,, ,,	inside cylinders	73 per cent
,, minimum ,,	outside cylinders	8·5 per cent
,, ,, ,,	inside cylinders	9 per cent
Wheels, truck, dia		2ft 10in
,, driving ,,		4ft 8in
Boiler, dia.		6ft 2in
,, length between tube-plates		19ft 4in
Steam pressure, per square inch		235 lb
Heating surface, firebox		194 sq. ft
,, ,, large tubes		1134 sq. ft
,, ,, small ,,		1231 sq. ft
,, superheater, Schmidt		1080 sq. ft
,, surface total		3639 sq. ft
Grate area		49·14 sq. ft
Tractive effort at 75 per cent		56,487 sq. ft
Factor of adhesion		3·7
Speed limit		53 m.p.h.

The engine differed from the French machine of the day before in being arranged for right-hand driving and hand firing. From the look of the coal, chauffeur Markowski was going to have his work cut out, the profile (Fig. 3) showing that the gradients, though not so severe as yesterday's, were almost entirely adverse for four-fifths of the distance to Conflans, and the coal couldn't very well have been worse; it was almost entirely dust. Further, the train of eighty wagons weighed over 1700 tons, and—to return to the profile briefly—it was evident that Markowski's task would get progressively

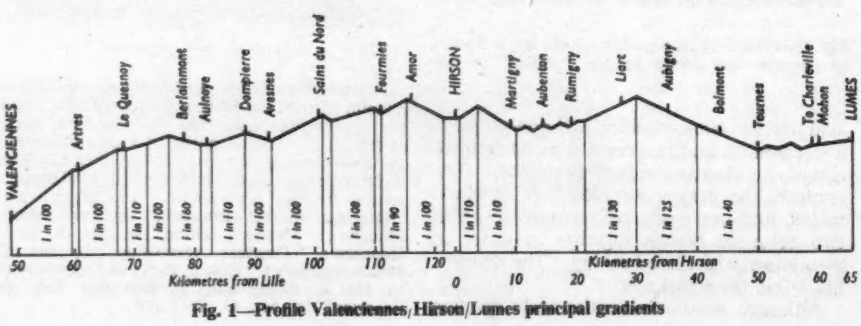


Fig. 1—Profile Valenciennes/Hirson/Lumes principal gradients

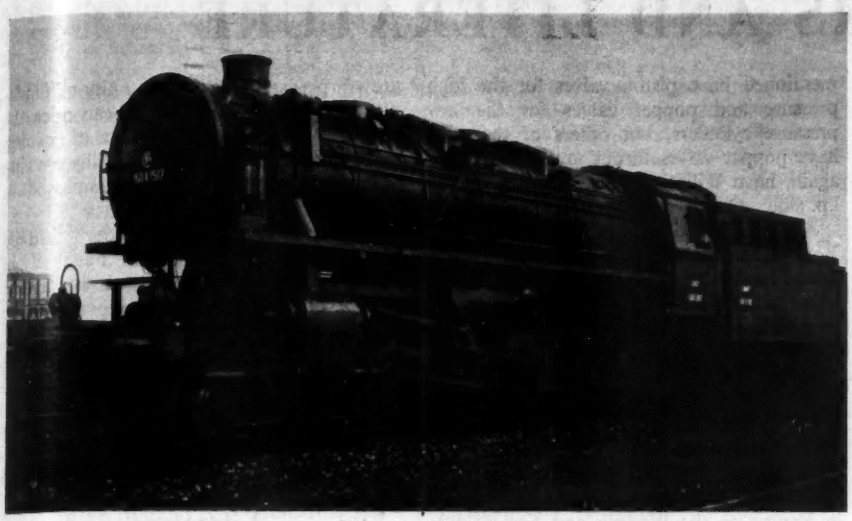


Fig. 2—2-10-0 freight locomotive, Class 150X

harder the farther we went, simultaneously with probable clinker formation on the grate and ash-clogging in flues and smokebox, from 60 miles of collar-work. Well, we should all find things interesting, no doubt; meanwhile, I was glad Monsieur Forray's forecast of a comfortable cab was justified; it was not only roomier than that of the day before, but gave better protection from the keen wind that had so worried me then, and which unfortunately was still blowing.

Getting long, heavy screw-coupled trains such as this into motion calls for careful application of power and gentle acceleration, but mécanicien Bourlier knew all about the business; a certain amount of slack between the trucks and the theoretically more even torque of three cylinders made "one-at-a-time" starting possible, and reduced the risk of snapped draft gear. Once on the move—at 10.31 a.m.—the fire-irons promptly went into action, and subsequently at frequent intervals, owing to the wretched coal, about the worst I saw in France. The irons were stowed in a tunnel under the bunker, run straight forward into the firebox and withdrawn in the same way, without the necessity of turning them end-for-end *en route*, an asbestos rag protecting Markowski's hands from the hot ends. He was kept busy enough, but I have seen firemen worse off—and have hated to do so. Little and often was his rule—very often, in fact, only the softness of the exhaust due to a Kylchap blast pipe keeping it from being more often still, and prevented the fine, dusty fuel being pulled right through the firebox into the flues. I have a Kylchap blast pipe in my notes, anyway, though the official dimension sheet of this "150X" class does not include it, so this engine must have been an exception. An appropriate lament applied to this coal occurs to me—"dust to dust, and ashes to ashes"—there was nothing in the bunker bigger than a pea.

The engine was in good shape, and riding well, though as the speed seldom rose much over 25 m.p.h. it had little excuse for cutting capers. The gradient was predominantly upward for many miles, with incessant minor fluctuations, but there was nothing worse than 1 in 200 as far as Montmedy, where, after a drop at 1 in 160, another saw-tooth climb began, getting steadily steeper as the Arrancy peak was neared. The profile only brings out the general trend and ruling figures; actually, the variations were perpetual, up and down, with very little level going. The country was open and rolling, with no very striking features, but several times I noticed overgrown concrete block-houses and rusty steel cupolas, derelict and forlorn—the Maginot line, that monument of strategic error, wasted labour and frustrated purpose. Montmedy and noon coinciding, a halt was scheduled for lunch, axlebox and brake inspection, some long and steep descents lying ahead, between Arrancy and Conflans. All braking was controlled from the engine and front of these trains, there being no guard's van at the rear, the air brake evidently being considered to make this redundant. The signals along here were automatic colour-light, with "distants" audible in the cab, as is the universal practice in France, and has been for many years.

The cab was, as forecast, more roomy and comfortable than that of its French counterpart, and the fittings and general arrangement showed the engine's Teutonic origin. The regulator was of the old Great Northern "pull-out" type, very easy to operate; the feed water heater was a "Knorr," as also was the brake pump, in place of the usual Westinghouse, and the drive right-hand. The wheel arrangement was new to me, the leading axle being associated with the first driving axle to form a "Kraus" truck. The engine had not been steaming too well at first, partly because of the poor coal, but also because of a hole in the fire—it is difficult to plug a hole with dust! However, something and some way were found to do it, after which the pressure rose steadily to the proper point, and stayed there, despite the constant upward climb, in which there was scarcely a break. Mécanicien Bourlier was rather critical of this engine, though personally I could not see much the matter with it. I imagine his dissatisfaction stemmed chiefly from the fact that it did not belong to his shed, a complaint I have heard before; enginemen have much in common the world over; local loyalties affect judgment.

Single-line working was necessary through a couple of tunnels near Vezin, in which conductor wire was being strung for electric traction; approaching Longuyon, on 1 in 200, there was a brief slip due to the combination of gradient, drizzle and a sweeping curve. The gradient stiffened through Arrancy; it was real hard slogging here, the speed dropping to 10 m.p.h., the weather making things all the worse—rain and bitter wind, more like winter than September. The fire-irons were used more than once over this stretch, and I wondered if they were of some heat-resistant metal, as the rake, though inside the firebox for quite long spells, never seemed to get red-hot or out of shape. On British engines one often sees an iron weakly bend into strange formation and have to be straightened on the spot.

At little more than walking pace the high, windswept ridge was surmounted, and the peak passed at 1.25, with the sun struggling through the racing clouds and a nipping wind swirling into the cab, forcing me to hug the back-plate and curse myself for not bringing more clothes. Once over the top, the speed quickly rose to 40 m.p.h. down a 1 in 160 descent to Spincourt, with the train under full control, ready for any emergency. It is indeed high time British freight and coal trains were air-braked. The riding was very good, with no opposing motion between engine and tender, and better than that of the French engine the day before. In justice to the latter, it was an aged machine, whereas this German engine was probably a war-time or post-war production. Looking down from Gandrecourt over the Auvergnes, there was an inspiring spread of country below, with Conflans at the foot of the steep, winding descent; once again the perfect control by the Westinghouse brake impressed and reassured me. The train came to a stand in Conflans at 2.04, having covered the 88 miles from Lumes, stops included, in 3 hr 33 min, averaging 24·7 m.p.h., a good performance considering the load and very adverse profile. Thence by car, through pretty country, 25/30 miles to Thionville and lunch, badly needed. A fine city, Thionville, well worth inspection, which was given to it for an hour or more, in company with Monsieur Forray, until I finally had to cry off, literally stiff with cold—"Mon ami! I am very sorry, but unless I can get into the warm, have rum and milk and go to bed, I shall probably collapse with pneumonia!" Monsieur Forray, kind soul, deeply concerned, immediately arranged everything, otherwise this article would never have been written. Some of my French locomotive experiences were tough, and none more so than these over the Eastern Region, this one in particular.

(To be continued)

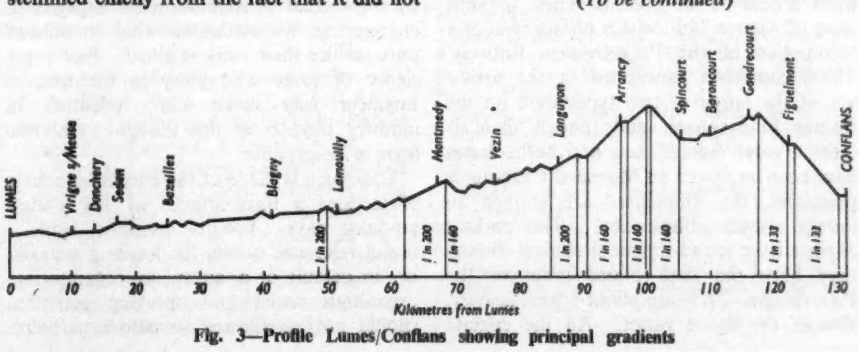


Fig. 3—Profile Lumes/Conflans showing principal gradients

LETTERS AND LITERATURE

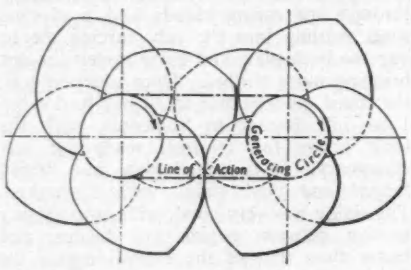
Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ONE-TOOTH PINIONS

SIR,—I see in your paper of August 10, 1956, an article by Professor W. A. Tuplin. An engineering acquaintance of mine, Mr. M. A. I. Jacobson, of the Development Department, Austin Motor Company, mentioned that Professor Tuplin had a model of gears consisting of two one-tooth pinions that meshed together, but turned in the same direction. Years ago I sent you a letter on this subject, published in THE ENGINEER of June 22, 1923.

The late Mr. Sykes, of the Power Plant Company, used to come and see me when he came to Austins from time to time. On September 4, 1928, I showed him my



brass model and asked him to see if two of his one-tooth pinions, both of the same hand, would mate together and turn in the same direction. He said he would try this. He was just going to America and asked my full name so that he could associate me with the idea. I think he died soon after, but later a representative of his firm told me it had been made and caused considerable interest.

I am wondering if Professor Tuplin's model is the one I proposed, but never saw, or perhaps he arrived at the idea separately.

You published a letter of mine on this subject in your issue of June 15, 1945.

F. E. LINDSAY

Birmingham,
August 23rd.

[We reproduce the drawing that accompanied Mr. Lindsay's original letter.—ED. THE E.]

FRENCH LOCOMOTIVE EXPERIENCES

SIR,—I am greatly enjoying Mr. Livesay's second series of "French Locomotive Experiences," as I did the first, but I do feel that it is a little misleading to illustrate the third article in the present series, in your issue of August 24th, with a photograph of a locomotive of the Paris-Orleans Railway. The locomotives mentioned in the article are of the larger of two types used on the former Etat system, and though there is quite a close resemblance, and both classes have been improved on Monsieur Chapelon's principles, the differences are enough to justify another illustration. The ex-Etat engines have round-topped fireboxes, though they have the flask-shaped grate of the P.O. design. They are about 5 tons heavier, though the figure varies. All the engines mentioned have piston valves for the high pressure and poppet valves for the low pressure cylinders, but others of the class have poppet valves throughout, and others, again, have Willoteaux piston valves on the l.p. side. Only a few have double chimneys.

An important difference lies in the tender. Your illustration shows the Nord 8000-gallon tender, which is not provided with a water scoop, whereas the Etat tender is longer, has a scoop between the bogies and carries 5000 gallons of water and up to 12 tons of coal, according to the type of "rehausse" fitted.

I am not finding fault with a delightful series of articles, but simply wish to draw attention to the large Etat "Pacific," of which there are several hundred in service in France on the Western and Eastern systems, and which is a machine of sufficient importance to warrant an illustration of its own.

J. T. VAN RIEMSDIJK

London, N.2.
September 5th.

ENGINEERS AND PHYSICISTS

SIR,—Your editorial of August 31st and the report on Sir George Thomson's British Association address interested me greatly, having already experienced in two industries some of the difficulties which can arise between engineers and physicists or chemists. May I question, with all respect, whether these efforts to establish a clear definition are really necessary ?

The natural universe is a single unity and there is basically only one scientific discipline. The demarcation lines between the study of different aspects of this unity are arbitrary and man-made. They are useful as rough guides to describe the particular facets or techniques which interest a person ; but the further a man progresses or an industry develops the more they must operate in regions where clear definitions are neither possible nor desirable.

There is a fundamental difference between the pure scientist, dedicated wholly to the pursuit of knowledge and truth, and the applied scientist, concerned to extract from that knowledge benefits to mankind. Few men, however, fall completely into either category. The great majority of us, even if having a tendency to one extreme, are impelled by both considerations in varying proportions at different times.

If the charter of our senior engineering institution is examined, one is forced to conclude that all scientists when motivated by the second consideration are engaged in engineering, no matter to what branch of pure science their work is allied. Past experience of some who glory in the title of Engineer may make many scientists in industry shudder at this thought ; but the logic is inescapable.

Too much is made of the particular course of lectures a man attends in his undergraduate days. Faculty divisions, while a useful reference system for locating lectures, or, in default of a collegiate organisation, organising social and sporting activities, should not be allowed to deform a man's growth permanently. If the unity of fundamental approach is realised it can open the way to a more rational structure of training and nomenclature among the rapidly growing number of applied scientists employed in industry.

This has indeed led back to your "attitude of mind." Woolly it may be ; but surely in trying to define anything as elusive as the essence of a profession, it is better to be vague than positively inaccurate.

K. L. STRETCH

Seascale,
Cumberland,
September 5th.

Literature

Clock and Watch Escapements. By W. J. GAZELEY. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 40s.

THIS work is clearly intended to be a companion volume to the previously published book, *Watch and Clock Making and Repairing*, by the same author. It is, indeed, in some ways, an amplification of Chapters 8 and 9 of the earlier book, and is designed to deal with the same important aspect of horological mechanism in a much more extensive manner than is possible in two chapters of a general work on clocks and watches.

In the increased space at his command, Mr. Gazeley deals with a tremendous variety of escapements, some of which are in everyday use, whilst others will be strange, even to many who are well versed in horology. In general, the escapements are mentioned in the order of their invention, though this method is not followed where there is good reason to depart from it on the score of a better understanding of the mechanism to be described.

The same clarity of description that characterised the earlier book is to be found in the present volume, and the illustrations, too, are, on the whole, good and well planned. Quite a number are identical with those used in the earlier book, and this is good, for, in such cases, they are often used as the general diagrams, and are supported by additional drawings which show the details of the escapement concerned in a more comprehensive manner.

The book is divided into two main sections, the first dealing with clock escapements, and the second being devoted to those used for watches and chronometers. The first chapter of the clock escapement section deals very thoroughly with the verge escapement, and is both interesting and valuable, for, although this very early form of escapement is now quite obsolete, there are still many antique clocks that are fitted with it, and this account of its design, together with the very detailed instructions on the correct methods of repair, should enable these to be kept in good order.

The chapters on the recoil and dead-beat escapements that follow cover practically all the variations of these two much-used escapements that are to be found on many different types of clocks. It is very surprising to see the number of modifications of the dead-beat escapement that have been devised, but, as the author explains, the differences in these are more apparent than real.

When he deals with the crutches used to

link both recoil and dead-beat escapements to their pendulums, Mr. Gazeley describes one or two adjustable forms, but omits several of the excellent modern crutches to be found on present-day movements. These are so well designed that they might well have been mentioned, and their construction described.

Gravity escapements form such an important group that, as is to be expected, they have been given a chapter to themselves ; but the author does not seem to be so happy when dealing with these escapements as he is with other forms. He does not mention the earliest successful gravity escapement, the Bloxam form, and his illustration of the double three-legged form seems rather badly proportioned, with a clumsy double-three-legged wheel. Most tower clock makers design these wheels to be as light as possible to minimise inertia and reduce the shock on locking. In his comment on the single-four-legged form of gravity escapement, Mr. Gazeley seems to imply that it was little used on tower clocks. Actually, it was used by several makers, and many large tower clocks are in service with this form of escapement, for the slower rotation of the escape wheel gives it advantages in some circumstances.

But the point at which issue must be taken with the author is the statement in his description of the double-three-legged type that when the arms are mounted on steel springs instead of falling by gravity, "the action is the same." The action of springs varies and such an escapement has forfeited the main source of accuracy—the constancy of the force of gravity.

In the second section, the main part of the descriptive matter is devoted to the lever escapement, for this is probably the most widely used escapement in the world. At the same time, the chronometer escapement is given ample space, and this is as it should be, for its development is one of the outstanding horological achievements, and the escapement is without parallel when extreme accuracy is essential. Other escapements, such as the cylinder, duplex and virgule, which are only rarely met with in these days, are dealt with very fully and capably. Such descriptions are of special value in a work on horology, for, although they may not be in general use, or may have ceased to be made for many years, clocks and watches are such long-lived machines that quite a number of examples are likely to be met with by the horologically inclined.

The chapter on the lever escapement is obviously the work of a horologist who knows both what he should impart and the most effective way of imparting it. The result is a very soundly written survey of the various kinds of lever escapement in current use, followed by a summary of a number of earlier forms. From these, Mr. Gazeley passes to instructions for making a lever escapement, and although it seems rather doubtful if such a complex piece of mechanism can be made entirely from a written description of the methods of production, the details are very complete and thoroughly good so far as they go.

It may be remarked that it is strange that so many horologists who have to deal with lever escapements have such a limited knowledge of the finer points of their action, but this, unfortunately, is only too true. The very complete account of the functioning of lever escapements, and of their adjustment, that is given in this work should do a great deal to improve the technical knowledge of those who read it, and to underline the care that is necessary if the utmost possible precision of performance is to be attained.

In its closing chapters, the book departs from actual escapements, and deals with the use of the depthing tool, and the methods used to polish various parts of horological mechanism. Although, in general, the book is very carefully written and deserves commendation on that account as well as on others, there are several errors that could have been avoided by more careful proof reading, and by checking the relation between the text and the illustrations. Errors of this kind, though small in themselves, can be somewhat misleading. These criticisms are, however, small points, which detract little from the praise which the book deserves, and which must be given in full measure. As a source of information on a most important section of horological work, it is both efficient and reliable.

An Introduction to the Theory of Structures. By W. MERCHANT and A. BOLTON. Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 30s.

AT some stage in their careers most university lecturers, and there are many, must feel they want to write a book on the subject they teach. Some no doubt think it is expected of them ! It must be difficult to-day to be original about the theory of beams ; that privilege was for Clapeyron, Muller-Breslau and Clerk-Maxwell. The fact is that the shelves of our technical libraries are cluttered up with books on this subject—all almost identical chapter for chapter. As years go by the books get fatter, contain more worked examples, more exercises and get more expensive. What a relief, therefore, it is to come across a textbook with a difference ! For that is precisely what the authors have produced in their well-written and beautifully presented book.

The preface gives a short and masterly exposition of the philosophy of structural theory and is followed by twelve chapters dealing with statics ; simple, encastré and continuous beams ; trussed frameworks ; deflections, stress and strain ; stress distribution in the interior of members ; the use of theory in design, moving loads ; pillars and moment distribution. As the title indicates, the book is an introduction to the theory of structures and stops short of the more advanced problems such as are involved in the solution of Vierendeel girders, multiple continuous portal frames, and elastic encastré arches. The authors have done well to devote some space to the classic Three Moment Theorem before going on to Moment Distribution. It is particularly pleasing to see that they have given the general solution of the Theorem which allows for settlement in the supports. The method of Moment Distribution is well explained and the general case providing for side sway is dealt with fully. The reader will find Chapter VIII on the use of theory in design stimulating. This chapter might well have come at the beginning of the book, where it would have made a good general introduction and helped to foster the right frame of mind in the student. This is a book that can be warmly recommended.

Solution of Problems in Aerodynamics. By S. A. URRY, B.Sc. (Eng.), A.F.R.Ae.S., Sir Isaac Pitman and Sons, Ltd., Parker Street, London, W.C.2. Price 32s. 6d.

FOUR hundred questions on aerodynamics are included in the fourteen chapters of this little book, many taken from the examinations of the professional societies. In each chapter complete solutions are given to about half the examples and answers alone for the remainder. The chapters begin by setting out the formulæ needed, but a complete table of symbols would be a valuable addition. Definitions are based on British Standards Institution recommendations ; it is, perhaps, a pity that the conventional three axes are not evoked in the chapter on equilibrium and stability. Performance calculations are confined to propeller-driven aircraft, and there is a chapter on airscrew theory. The last chapter is devoted to viscous and compressible flow ; the examples here are mainly of theoretical interest, and there is no hint of the immense power of boundary layer control to modify the main flow (the explanation of the Handley Page slot would earn few marks), and only an oblique suggestion of the existence of wave drag. There are, however, numerous references to relevant reports and a comprehensive classified bibliography.

Solution of Problems in Telecommunications. By C. S. HENSON., B.Sc., (Eng.), A.C.G.I. A.M.I.E.E., Sir Isaac Pitman and Sons, Ltd., Parker Street, London, W.C.2. Price 25s.

UNIFORM with the above-mentioned volume, this book is generally similar except that some theoretical work and the references appear at the beginning of the chapters. There is thus no bibliography, but a table of symbols does appear. The problems, however, are largely of final degree standard. All the normal studies in circuitry are executed, culminating with an elementary exposition of aerial theory. The penultimate chapter is devoted to acoustics, principally with application to loudspeakers and microphones, and the last to cathode-rays and power rectifiers.

Books Received

Peaceful Uses of Atomic Energy. Vol. 4, *Cross-sections Important to Reactor Design.* A United Nations Publication. Sales and Circulation Section, Department of Public Information, United Nations, New York, U.S.A. Price 54s.

Peaceful Uses of Atomic Energy. Vol. 5, *Physics of Reactor Design.* A United Nations Publication. Sales and Circulation Section, Department of Public Information, United Nations, New York, U.S.A. Price 63s.

Use of Light Waves for Controlling the Accuracy of Block Gauges. Second edition. By F. H. Rolt. Hilger and Watts, Ltd., 98, St. Pancras Way, Camden Road, London, N.W.1. Price free, postage 6d.

Selected Combustion Problems : II.—Transport Phenomena : Ignition, Altitude Behaviour and Scaling of Aero Engines. Butterworth Scientific Publications, 88, Kingsway, London, W.C.2. Price 90s.

Information Theory and its Engineering Applications. Second edition. By D. A. Bell. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 25s.

Bibliography, Hardness and Hardness Testing, from 1937 *to* 1955. Industrial Diamond Information Bureau, St. Andrew's House, 32–34, Holborn Viaduct, London, E.C.1. Price 5s. 6d.

Body Engineering Design and Construction of Motor Vehicle Bodywork. Second edition. By S. F. Page. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 25s.

Frequency Modulation Engineering. Second edition. By Christopher E. Tibbs and G. G. Johnstone. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.

Power Production : The Practical Application of World Energy. By Hans Thirring. George G. Harrap and Co., Ltd., 182, High Holborn, London, W.C.1. Price 25s.

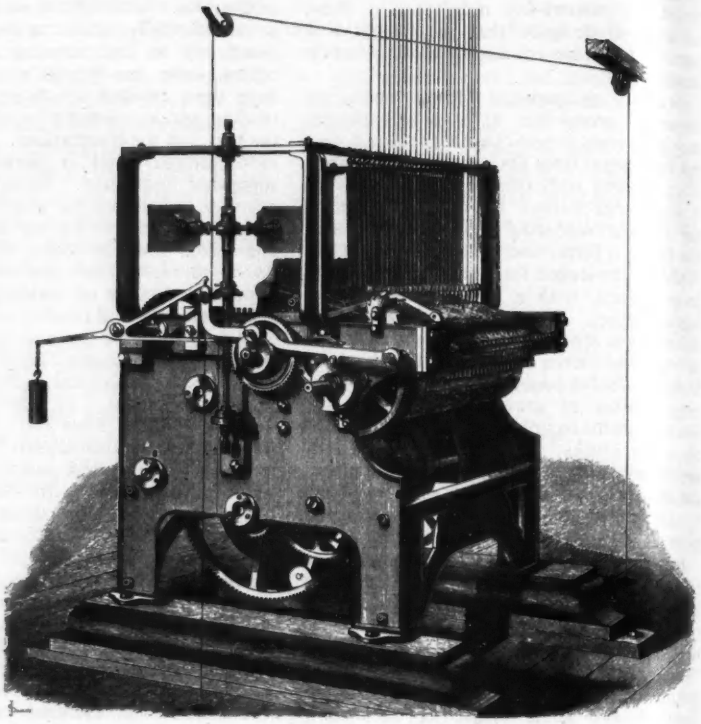
Guide to the Coalfields, 1956. Edited by R. H. Walkerdine and E. G. Corbin. The Colliery Guardian Company, Ltd., 30–31, Furnival Street, London, E.C.4. Price 20s.

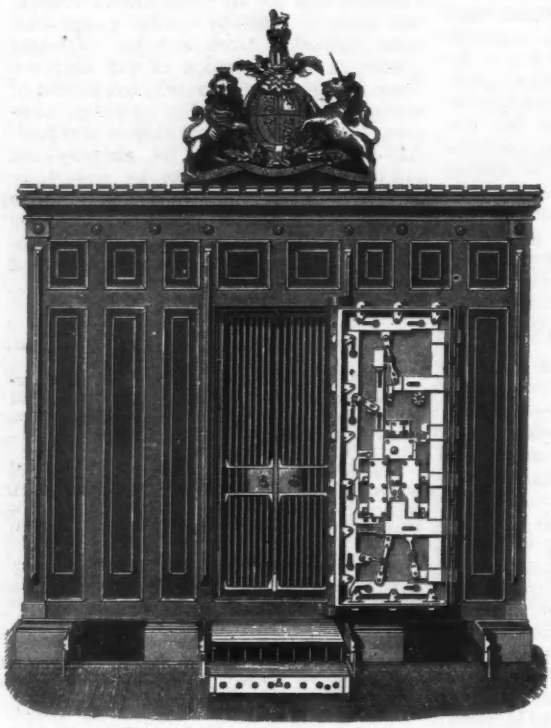
Einführung in die Technische Thermodynamik und in die Grundlagen der Chemischen Thermodynamik. By Ernst Schmidt. Springer-Verlag O.H.G., Berlin, Price DM.30.

Metallurgy of the Rarer Metals, No. 5 : Molybdenum. By L. Northcott, Butterworth's Scientific Publications, Ltd., 88, Kingsway, London, W.C.2. Price 40s.

ENGRAVINGS OF 1875

The carillon machine, which is shown in this engraving (right), was made by Gillett and Bland, of Croydon, for Shoreditch Parish Church. It was described in some detail in our issue of August 13, 1875. It is not possible here to reproduce all the particulars. Our description explains that "the hammers (for striking the bells) are always kept raised, and are only allowed to drop by the agency of the musical barrel. The instant they fall they are lifted again, and so long as the lifting is accomplished quickly enough, the time of lifting has nothing to do with the production of the air. That is determined solely by the musical barrel, which, being relieved of the work of lifting, has little or no strain on it, can be made small and light, and will always revolve at the same rate, and so insure that the tune shall be played in perfect time." When the description was published, we ventured to think that such a carillon machine was "about as ingenious a combination of mechanism as is to be met with in the range of the arts."





In our issue of September 17, 1875, there appeared some engravings of a banker's strong room constructed by Hobbs, Hart and Co. One of them is reproduced here (left). The dimensions of this room were 12ft high, 14ft wide and 7ft 6in deep. The description goes on to say that the strong room "is constructed of sixty-two divisions, all of which are most accurately fitted, upwards of 32,000 holes having been used. There is an elaborate base or false bottom formed of plates $\frac{1}{2}$in thickness, on which are placed girders to support the room, forming thereby a chamber underneath the safe designed to prevent the room from being tunnelled into. The whole of this chamber is enclosed by doors, etc." We added that the door as well as the body of the room was formed of iron and steel welded together, and that the weight of the door alone was nearly 2 tons.

The impression of the bridge over the Severn, on the Severn and Wye Railway, which is shown in the engraving below, was first published in our issue of August 27, 1875. The foundation stone of the first pier had recently been laid, and the bridge was "in course of construction." The description reads: "On the north side of the river the bridge will be approached by a masonry viaduct consisting of twelve arches, about 70ft in height, and on the south side of the river will terminate by an iron swing bridge over the Gloucester and Berkeley ship canal. The total length of the bridge, including the masonry viaduct and swing span, will be 4162ft. The total weight of iron in the Severn Bridge is about 6800 tons. The contractors for the bridge are Hamiltons Windsor Iron Company, Liverpool. The price is £190,000."

Tesla's Contribution to Electrical Engineering

By REGINALD O. KAPP, B.Sc., M.I.E.E.

NIKOLA TESLA, the great Serbian scientist, was born on July 9, 1856, and his centenary was celebrated in Belgrade this summer. Among the things we owe to him are the three-phase system of electricity supply and the principle of electromagnetic resonance. He demonstrated wireless transmission and reception, moreover, in 1893 to the Franklin Institute and Electric Light Association of America, long before Lodge and Marconi.

Tesla's three-phase system arrived at a time when the more far-sighted engineers, such as Ferranti in this country, had come to recognise that full advantage could only be taken of the great mobility and convertibility of electricity if this were transmitted in the form of alternating current. Until the eighties of the last century no one could have foreseen the direction in which the road to progress would lead, least of all that it would lead into the domain of alternating current. The equipment of teaching laboratories in those days included Leyden jars, pith balls, electroscopes and other devices for the study of uniform electrostatic fields ; it included magnets and batteries from which current might be drawn to energise them ; it included perhaps a small dynamo provided with a commutator and capable of supplying direct current. In those days students were educated to be d.c. minded.

Tesla was among those who recognised very clearly that the commutator was the weak factor of the existing d.c. machines. Having spent much wasted effort in the attempt to invent a commutatorless dynamo, he turned his attention to the problem of producing an a.c. machine that would have at least one great advantage over the d.c. one, namely a steady torque. That is the characteristic feature of the three-phase induction motor, which Tesla patented in 1888 and announced in a paper read before the American Institute of Electric Engineers in the same year. Its basis is the rotating field.

There is some doubt as to whether the Italian Ferraris or the Serb Tesla first thought of the geometry of the rotating field ; but there cannot be any doubt at all that Tesla was the first to appreciate its dynamics. It was he alone who saw clearly that such a field could be devised powerful enough to drag a rotor with it and to work machinery that was coupled to the rotor. Here the step from geometry to dynamics is a big one ; it is the step from a piece of laboratory ingenuity to a great advance in engineering. It could only have been taken by a man with a very original kind of mind.

To-day we are so familiar with three-phase supplies that we may well forget what intellectual subtlety went to the invention of the polyphase system. Before Tesla's day a magnetic field appeared to be firmly attached to the piece of metal in which it originated. The lines of magnetic flux were thought of as emanating from an iron armature and as being secured to this somewhat as bristles are secured to a broom, i.e. as moving when the armature moved and at rest when the armature was at rest. The notion that the lines of magnetic flux could slip over the armature, that an invisible moving field could be produced by stationary metal was quite alien to the way most people thought sixty years ago. They must have been startled at the notion that a magnetic field could rotate when it was produced by copper conductors and iron that did not do so.

Tesla's invention came just too late for Ferranti's pioneering scheme, the generation of a.c. by 10,000 h.p. alternators and its transmission from Deptford to London at 10,000V. For that scheme had been designed by then and the Deptford station was opened in 1889. But C. E. L. Brown and Dolivo von Dobrovolski were quick to recognise the advantage of three-phase current and used it for the historic transmission over 100 miles, at 30,000V, from generators driven by water turbines in Lauffen, to Frankfurt, an undertaking that became the sensation of the Frankfurt Exhibition of 1891. The lighting of the Chicago World Fair by polyphase current followed in 1893. In the same year a contract was awarded to the Westinghouse Company for three 5000 h.p. Tesla polyphase generators. They were for the Niagara Falls project, for which during the preceding years many other schemes had been considered and rejected. Following those early ventures the rotating field was set spinning throughout the civilised world and a long association between Tesla and the Westinghouse Company was established.

Having turned his attention to a.c., Tesla set himself the task of producing currents at ever higher frequencies and voltages. He first constructed alternators with hundreds of poles, from which he obtained a.c. currents at 10,000 cycles per second. But when he wanted to achieve still higher frequencies he found that attempts to do so by mechanical means led into a blind alley just as his earlier attempts to design a commutatorless d.c. machine had. Once more he turned in a new direction and the imaginative course that he pursued revealed the consistency of his scientific outlook. One may say without being unduly fanciful that the Tesla induction machine was based on the invention of the invisible magnetic wheel. In this sense his solution of the new problem was to invent the invisible electromagnetic pendulum. It is produced in what is now called the Tesla coil and embodies the principle of electromagnetic resonance. This coil consists of magnetically coupled circuits in which an electric charge swings to and fro just as a visible pendulum does. In the visible pendulum energy appears alternately as potential energy of position and as kinetic energy of motion according to whether the pendulum is at the extremity or the middle of its swing. In the Tesla coil the energy appears alternately as that of an electrostatic and an electromagnetic field.

In this coil a spark is used to initiate the oscillation. To reduce the damping effect of the circuit a blower is used for extinguishing the spark. Very high voltages were obtained, giving sparks said to have been up to 22ft long. Insulation of the coil created a new problem, which Tesla solved by using a liquid dielectric, oil. Its use is familiar to-day, but at that time it could only have been thought of by a man with exceptional experimental ingenuity.

With his coil Tesla produced many phenomena for the first time that have since been pressed into the service of man. Among them are the light from an electrodeless luminous discharge tube, the various physiological effects of high-frequency currents, and the wireless transmission of electromagnetic signals. Before the end of the last century Tesla coils were a common feature of most teaching laboratories and the sensational experiments to be performed with its help were shown for many years in popular lectures.

In the early 'nineties Tesla erected a large experimental station in Colorado where he pursued his researches in high-frequency, high-power electric current. From there he succeeded in 1898 in lighting electric lamps at a distance of over half a mile without any intervening wires. But his experiments in wireless transmission seem, unfortunately, always to have been directed to the transmission of power in large quantities. There is little evidence that he appreciated that the true field of wireless was in telecommunications. However, one of his achievements was to steer a model ship by wireless, patented in 1898.

Although Tesla lived to the ripe age of eighty-three and continued to work in his laboratory for nearly the whole of his life, the last fifty years did not produce anything of value. The years of achievement covered barely a decade. Several circumstances may account for this. He was essentially a lonely man. He never married and, wide though his circle of acquaintances must have been, he had no cronies. He must have lacked the stimulation and guidance that come from the close association of mind with mind. He must also have lacked self-criticism. He patented 900 inventions during his lifetime, a number only to be reached by one who admits every one of his bright ideas without scrutiny and rejects none. His enormous inventiveness and experimental ingenuity were, moreover, not balanced by insight into basic principles. His mind turned more to making things than to understanding them. Eager to know what would happen if this or that were done he had not much curiosity about why. That caused him to give too much of his attention to " gadgetry " and too little to arithmetic, so that he often lost his sense of proportion and too readily yielded to the fascination of the very big and the sensational.

All that only means, however, that, like some other men of genius, Tesla had his limitations. There remain those ten years of achievement without which the world would be very much poorer to-day.

Tesla Centenary Celebrations

The Tesla centenary celebrations in Yugoslavia were organised by a government-sponsored national committee with Professor Damianovitch, of the University of Belgrade as secretary. More than fifty scientists from twenty countries were invited to attend the celebrations, which began with a reception held in Belgrade on the actual anniversary of Tesla's birth, July 9th. The next morning there was a session at which tributes to the work of Tesla were paid in short speeches by official representatives of major international scientific organisations, national bodies and universities. Sir Arthur Fleming conveyed a message from the Institution of Electrical Engineers, and Dr. Dunsheath, as president of the International Electro-Technical Commission, happily used the occasion for the first public announcement of the news that the Commission had, at its meeting in Munich, during the preceding week, resolved to recommend the name of

Tesla for the M.K.S. unit of magnetic field strength—a unit more often called the Weber per square metre in this country. The subsequent programme in Belgrade included eighteen short lectures devoted either directly to Tesla's work or to developments that had sprung from it; the first lecture was by Professor Niels Bohr.

A tour of the country followed the celebrations in Belgrade and included a visit to some large copper rolling mills in Sevogno, to the Litostroj turbine factory in Ljubljana, the electrical factory Rade Koncar in Zagreb, the Jablanica power station (with its six 31,000 h.p. Francis turbines) not far from Sarajevo, and to the Nikola Tesla power station at the northern end of the Adriatic. The Nikola Tesla station works at a head of over 2000ft and is equipped with Pelton wheel turbines, each rated at 28MW. An interesting point is that it uses a restricted amount of pumped storage. The lake from which the water is drawn is rather small, but there is a much larger lake a few miles distant and at a level some 180ft higher. To avoid waste of water, when the lower lake is getting full, water is pumped to the higher one and allowed to return as and when required.

Directing Research

By H. E. WIMPERIS

IN this country the universities and the greater industrial establishments alike undertake scientific research work as and when they will. In universities the purpose will commonly be the "discovery of truth" in whatever field of thought may make most appeal to the investigator, who may be the professor himself, one of his staff, or some post-graduate student. The nature of the investigation may sometimes be suggested to the university from an outside source willing to bear the cost (though in this country the universities are commonly, and no doubt wisely, shy of undertaking any work or any investigation of a "secret" nature—differing here quite markedly from what is a common feature in the U.S.A.). But when the work undertaken lies, as it sometimes does, in the field of pure science, its possible use for industrial application of any kind may not be immediately apparent; and the scientists and their contemporaries in industry do not always "speak the same language," so that the presence at a conference of some intermediary who can do so and thus act as an interpreter is almost essential. Such persons are to be found in the small group commonly classed under the somewhat sweeping title of "Directors of Scientific Research" and that is one of their uses.

Such discussions have to cover a wide field. They need to include, not only the objectives at which the research is to aim, and the various possible means for carrying it out, but the nature and size of the staff necessary and, a very important matter, the degree of publication of the results which may be desirable or expedient. It hardly needs to be said that in all departmental discussions, and at all levels, however exalted, the Director of Research needs to be represented in person or by one of his chief officers. Anything written on this wide and important subject will be better understood when illustrated by specific instances, and when these are drawn from personal experience they will carry the more weight.

In a recent issue (July 6th) of this journal an announcement was made of an "international symposium" to be held towards the end of September at the National Physical Laboratory to discuss fully the various aspects of this subject. Its declared intention is that it should comprise those whose special responsibility lies in the direction and management of large research establishments, whether governmental, industrial or academic. It plans to begin with a session dealing with general problems, followed by separate group discussions on the questions of general organisation, staffing and communication. It is hoped to close with a plenary session dealing with the general conclusions reached. Since it will be the first international conference held in Britain on the general topic of scientific administration, it will be followed with close interest.

The Admiralty, always a pioneer among our Government Departments, first included a Director of Scientific Research in its headquarters staff nearly a generation ago, and added a special research laboratory to act under his personal control. One of the first duties involved was, of course, the choice of suitable recruits for a naval scientific staff, and later to advise on any subsequent changes of their location or promotion. The Air Ministry followed this precedent a few years later, adding to these duties that of the supervision of the scientific work undertaken by any of the various technical establishments of the Ministry, the R.A.E. at Farnborough being, of course, by far the largest. It happens that the present writer was the first Air Ministry D.S.R. to be appointed, and though he had, of course, to feel his way with a necessary measure of circumspection, he did receive most encouraging support, not only from the Air Council itself, but from the other two Service Departments, whose close co-operation was necessary in the national interest if overlapping was to be avoided. At about the same time the Air Council appointed a Director of Technical Development, a senior R.A.F. officer position, and one of the first tasks before the two new Directors was the division of staffs at the various experimental stations, and at headquarters, into "scientific officers" and "technical officers" to deal with the two branches of scientific research and technical development. The spirit in which this task was approached was indicated by a remark by the new D.T.D. to his colleague: "This is really our joint affair, but I would be very content if you did it for us both."

The recruitment of young men for the scientific research staff was an important duty, and it was soon found best for the Director to visit—especially in the earlier part of the year—those universities with the most successful record in the out-turn of able men in natural sciences and engineering, and arrange to interview a number selected for the purpose by the professor, who were in their third or fourth years of university life. Of them, a proportion would be offered two or three months' work in the ensuing summer at one of the Air Ministry establishments, usually Farnborough, and this often led to the discovery of real talent and to more permanent engagements resulting. This seemed to be a plan far preferable to leaving selection until after the results of the academic examinations were known, since such results so often depend on what happens to be the state of health of a candidate at the time, or even perhaps of that the examiners concerned!

Although in the Air Ministry the natural research objective was the general improvement in British aeroplane design, both as regards performance and structural strength, there were immediate developments in methods of air warfare to be studied also, from both the offensive and defensive points of view. A striking instance of the latter was afforded not long after the writer became directly involved in such duties: heavy clouds were seen to be gathering over international relationships—partly, no doubt, due to the great world depression of those days, but mainly through fear of yet another war with Germany—this time with a Hitlerite Germany. One of the unhappy aspects of this possible threat was the risk of intensive air attack on this country, and on the huge target of London in particular, the moment any such war started.

Air action against hostile aircraft seeking to attack Britain was the responsibility of the R.A.F., but the warning of their coming, with or without prior notice of war, was the task of the War Office and the observers in charge of the huge acoustical mirrors put up, and operated, by that Department. These mirrors, it may be here revealed, were far from being simple to use and so limited in number that it could almost be said that for effective use they needed a certain degree of co-operation on the part of the enemy! But since with the passing years the air speeds attainable by aircraft continued to rise steadily, whilst the speed of sound remained just as it was, it was manifest that the utility of any acoustic method of warning must get less and less effective just when it was wanted more and more. Something had to be done. What were the possible alternatives?

The task of any research director is scientific administration and not invention; he could not therefore be expected to give an adequate answer to this large question himself, and he had to consider where the best scientific assistance to this end could be found. Mere inventiveness was not sufficient, indeed there was no lack of co-operation on the part of private adventurers; in fact, the three Service Departments were at that time so inundated by offers of so-called "Death Rays" that it was decided on high authority that they should all be dealt with by the Air Ministry—which, of course, meant by its unfortunate D.S.R.

It seemed best in such circumstances as those above described to meet this new and urgent need, not least on the part of the R.A.F. itself, for a really rapid means of warning would be to select a small group of scientists to work with the Director on this particular problem—as well as on any others relating to air defence—the existing Aeronautical Research Committee being far too large a body for the rapid action necessary. This recommendation was put to the Secretary of State for Air, the late Marquis of Londonderry, who promptly agreed, and a small Air Ministry Committee for the "Scientific Survey of Air Defence" was appointed—some half a dozen men in all.

Immediately the committee got to work it became apparent that for warning purposes the one ideal alternative to the slow acoustic warning would be some form of radio beam. With the then existing system any hostile aircraft could have travelled several miles, and in any direction, before the warning signal arrived, whereas the corresponding uncertainty with any form of radio would be less than a centimetre! The normal interval between the sight of a distant lightning flash

and the sound of the thunder is an illustration. In its consideration of this initial problem the committee received most valuable advice from the responsible staff at the N.P.L., which suggested that experiments should at once be made on the lines of the "radar" methods being used in current ionospheric research work. It was a matter of a few days only before definite promise of success was found to be possible on such lines. Progress thereafter was exceedingly rapid and by the time war came in 1939 Britain had a long chain of warning radar stations ready for the warning and guidance of the R.A.F. fighters. The effect on the outcome of the Battle of Britain is well known.

At the present time one of the pressing problems of the day lies in the laying down of the principles that should guide civil airliner design. The demand for higher and higher air speeds comes partly no doubt from the travelling public and partly from the natural ambition of designers. But there should surely be a limit put to this ambition, for it makes runways long and costly and adds appreciably to the accident risk in landing: moreover it adds to the danger of air collision, since the possible speeds of approach (often in conditions of poor visibility) may reach values greater than can be met by the nerve and muscle reactions of the human body, which proceed at the same speed as they have ever done. In the July issue of the American journal *The Atlantic* there appeared an article by Colonel H. L. Moseley, U.S.A.F., on "The Challenge of High-Speed Flying." It is a timely publication, since there has been an alarming increase in the number of "near misses" of collision by civil aircraft approaching landing fields. Its author estimates that there is an interval of a tenth of a second before the brain knows that the eye has seen an object; four-tenths of a second before a decision from the brain can be transmuted into useful action; half a second before effective recognition of objects to be encountered in the sky, and, with luck, a couple of seconds to make the correct choice of action. So if he is flying at 600 m.p.h. the process should start at least half a mile ahead of any possible encounter—all too short a distance if visibility is appreciably restricted.

Another direction for future research lies in the growing field of guided missile design, including both of its current forms, the self-guided by self-contained radar and that guided from a parent ship or airfield. The navigational problems here involved can be exceedingly intricate, but given success in their development, such devices seem likely to change the older methods of warfare almost beyond recognition.

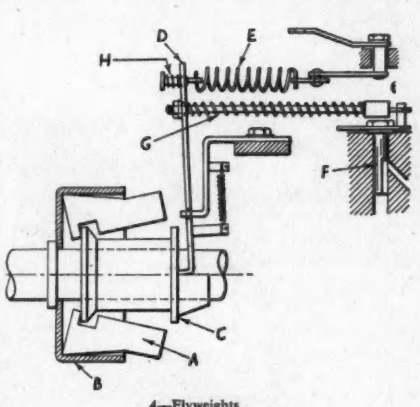
Has the coming of atomic power called for any change in the methods of research procedure above discussed? Certainly it has made the responsibility of those in charge materially heavier than it was, for the power that can now be released from uranium is vastly greater than anything previously known, whether with a military or a civil objective, and if in the future a means for the controlled release of thermonuclear energy should be discovered, there would hardly be any limits to the sum total of nuclear power thus made available to the engineer. Nevertheless, the general principles on which the direction of research is based would remain as they now are. The kind of research staff needed might have to be modified in some degree, but the growth of automation would in any case have been almost equally effective in its call for yet more and more skilled technologists.

On the whole the most marked change in the coming age is likely to be the nature of the armament called for by the three Fighting Services. The naval equipment in particular seems likely to suffer a drastic change: the great guns on the huge battleships of the past, with their highly complex gun-sighting problems, are being replaced by self-propelled missiles of which some will also be self-guided. The influence on submarine design seems indeed likely to be drastic. In the first world war the attack on enemy submarines was largely undertaken by aircraft-type bombs designed to explode under water as close to the target as possible; such bombs usually weighed 50 lb or so, with a charge of about 25 lb of T.N.T., and an exceedingly accurate aim was needed if the weapon was to be effective—much ballistic research on terminal velocities in air and in water was needed, some of which was carried out in the shaft of a Yorkshire coal mine half a mile deep and some of it in the open sea. But in these days an atom bomb (even of the Hiroshima type) can carry the equivalent of no less than 20,000 tons of T.N.T., whilst one of the hydrogen type can, it seems, be made many hundred times more explosive still. Whether any research work could produce a design of submarine which could live even in the distant neighbourhood of such a weapon seems more than doubtful.

Distributor Pump for Diesel Engines

THERE have been several attempts in recent years to escape, particularly on high-speed diesel engines, from the elementary approach to fuel injection of providing one pump cylinder for each engine cylinder and a camshaft resembling that of the engine. The need to phase evenly and calibrate uniformly the separate pump elements when the pump was in service contributed notably to the cost and difficulty of maintaining diesel engines. The new C.A.V. "DPA" distributor pump is based on the American Hartford design which has been used with great success in the U.S.A. on a variety of engines, and has now been modified by C.A.V. to meet the special requirements of British motor designers. Compared with the orthodox fuel injection pump, the distributor pump has only one pump element and a distributor supplying all cylinders in turn. The inherent simplicity of the design lends itself to compactness, ease of installation, convenient driving arrangements, and high-speed operation. Because of its simple design and construction the pump can be produced at lower cost than the conventional multi-cylinder injection pump, a factor particularly important in the field of small engines where the injection equipment represents a comparatively high percentage of the total cost.

The C.A.V. distributor pump can be briefly described as a single-cylinder opposed-plunger pump with variable stroke. The delivery stroke



A—Flyweights.
B—Retainer.
C—Thrust sleeve.
D—Control arm.
E—Governor spring.
F—Metering valve.
G—Cut-off spring.
H—Idling spring.

Fig. 1—Mechanical governor and metering valve

is actuated by positive cam action, while the variable admission stroke is effected by the hydraulic pressure of fuel oil, generated by a sliding-vane transfer pump. The variable intake stroke is controlled by the volume of oil admitted to the space between the two opposed plungers of the actual pressure pump through a metering valve. The intake of fuel to the said pressure pump is controlled by a rotary valve which also serves as delivery valve and distributes the oil flow from the pressure pump to the individual injectors. The pump has no ball or roller bearings, no gears, and no highly stressed return springs; it contains the same number of working elements for any even number of engine cylinders supplied. All running parts, including the metering valve of the governor, are assembled in a cylindrical steel casing in which pressure is maintained to prevent the ingress of dust, water and foreign matter during operation.

The main features of the pump and the principle of its operation are best seen in the sectional diagram, Fig. 2. The main rotating units are arranged on a common axis so that they rotate as one in the centre bore of the cylindrical pump housing. The drive shaft, linked at one end by suitable means with some appropriate engine drive, is connected by a splined coupling with the pumping and distributing rotor. The rotor comprises two parts, a short, large-diameter pumping section and a considerably longer small-diameter distributing section. A very close running fit between the distributor part and the corresponding central bore of the housing keeps the losses of oil pressure at a minimum.

The large-diameter section of the rotor has a transverse bore which forms the cylinder of the pressure pump. It contains two opposed plungers, operated through shoes and rollers by a stationary cam ring which is housed in the pump casing. The cam ring has as many internal lobes as there are cylinders to be supplied.

The distributing section of the rotor has a central bore which connects the space between the opposed pump plungers with radial bores controlling the intake and the delivery of the pressure pump. One radial bore controls the delivery ports which, equally spaced round the circumference of the central bore of the pump housing, connect with the pressure pipes leading to the individual injectors. At an intermediate position a number of bores, also equally spaced (four or six, according to the number of engine cylinders), constitute the intake ports. As the rotor turns, they align successively with a single port in the casing, thereby admitting fuel from the metering valve to the pressure pump.

The rotor, at its small-diameter end, carries the sliding-vane transfer pump, the eccentric liner of which is housed at the right-hand end of the pump casing. The casing is covered by an end-plate which contains the fuel inlet and a by-pass valve which controls the transfer pump pressure.

Fuel entering the pump through a filter in the end-plate (either under gravity or induced by a separate delivery pump) passes to the continuous-flow transfer pump and then through the metering valve to the reciprocating pressure pump. As the rotor turns, one of the radial bores of the transfer section of the rotor registers with the intake port in the pump casing, and fuel under pressure enters the cylinder of the reciprocating pump through the central bore of the rotor, separating the opposed plungers. As the rotor continues to turn, the intake port is covered, and shortly afterwards the radial delivery port aligns with one of the fuel delivery ports. At the same time the rollers of the pump

plungers make contact with the internal lobes of the cam ring and discharge the fuel to the corresponding injector. Fuel displacement ceases when the plungers reach the end of the inward travel imparted by the cam lobes, and shortly afterwards the distributor port closes, sealing off the fuel pipe to the injector. As the rotation of the rotor continues, the cycle repeats itself several times each revolution, the number of strokes being in accordance with the number of engine cylinders to be supplied.

Control and Governing

Control of the pump output is effected by means of the transfer pressure, in a manner reminiscent of the "Pressure/Time" system described in these columns on October 7th last. The regulating valve in the end-plate establishes this pressure: the transfer pump passes considerably more fuel than is delivered to the engine and maintains a continual flow through the valve. The small piston must compress the spring far enough for this oil to pass through the regulating port, and thus defines a relation between engine speed and transfer pressure: this relation, on a base of speed, will rise sharply in the idling and maximum speed ranges of the engine but, for reasons explained below, only gradually through the working range. The plunger can also move to the far end of the valve body, where it rests against a second spring: it does this when the fuel lift pump is priming the injection pump, since fuel cannot be forced through the vane pump. The fuel then flows through the priming port into the transfer gallery.

The transfer pressure characteristic decides the maximum torque of the engine—subject to a maximum travel adjustment on the plungers (not shown in Fig. 2). The driver controls the engine by means of the metering valve. This moves under the influence both of transfer pressure and the springs on the valve spindle. Considering first the full rack position, it can be seen that increasing transfer pressure will raise the valve against the governor spring and cut off the flow through the valve to the rotor: this limits the maximum engine speed. At any other rack setting the same effect will occur at a lower transfer pressure, so that this control acts as an all-speed governor: the relatively gradual change of pressure with speed in the working range enables the driver to obtain a satisfactory degree of control over torque. When the accelerator is released, the rack moves up to the idling stop. In this position the rack is in contact with both the governor spring and the idling spring when the metering valve is acting: thus, the valve is more sensitive to small changes in pressure. Improved idling is one of the benefits found in practice with this type of pump. The large plate at the bottom of the governor spring has a dashpot effect and suppresses any sudden movements of the valve. The fuel is cut off by a cam acting under the washer at the top of the valve spindle.

Transfer pressure is also used to actuate the automatic injection advance mechanism. As can be seen, the cam ring is rotated by a piston acted upon at one end by a spring and at the other by oil pressure.

The hydraulic governor is limited in its performance by the absence of temperature compensation, and a mechanical governor is also available. This is illustrated in Fig. 1. It is installed on the drive shaft adjacent to the cam ring and the pump housing is lengthened. Four flyweights are mounted in a cruciform carrier, and pivot about one sharp edge against the action of the governor spring. The opposite end of the governor spring is connected to the driver's control. There are three different initial tensions and three different positions, giving different leverages, for the spring anchorage. Mounted on the anchorage is the idling spring. The control arm is linked to the metering valve, which in this case is a shaft with a keyway that moves across the fuel port as the shaft is rotated. The light spring on this link allows the cut-off mechanism to close the valve against the efforts of the governor.

Fig. 3 is a view of a sectioned model of the distributor pump, showing the arrangement of the main components. Compared to a conventional four-cylinder pump, it is small and compact, and the convenient shape should enable the engine designer to mount and drive the pump in a manner which results in a notable simplification and reduction of engine cost, weight and bulk.

The pump is not, of course, indistinguishable in its action from a conventional Bosch pattern pump. Although the cam is shaped to give an unloading effect, delivery of fuel continues until the plunger comes to rest at its innermost point, so that the delivery rate is low at the end of injection. For this reason different nozzles, probably with different valve lifts, are required when a distributor pump is applied to an engine.

Various plunger sizes, from 4·5mm to 10mm, are projected: in all cases the stroke is approximately 2·2mm. The pump has been tested up to 2100 r.p.m., and while it is on engines of four or more cylinders that its cost advantage is great, a three-cylinder version might be justified for the high pump speeds needed for an engine running on the two-stroke cycle. The pump will be seen at the Commercial Motor Show this month, mounted on the 2260 cc engines of the Commer and Karrier ¾-ton to 2-ton goods vehicles, which develop 50 b.h.p. at 3000 r.p.m.

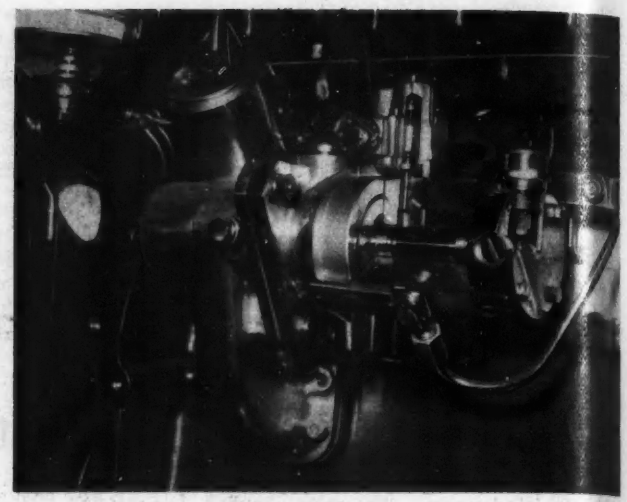
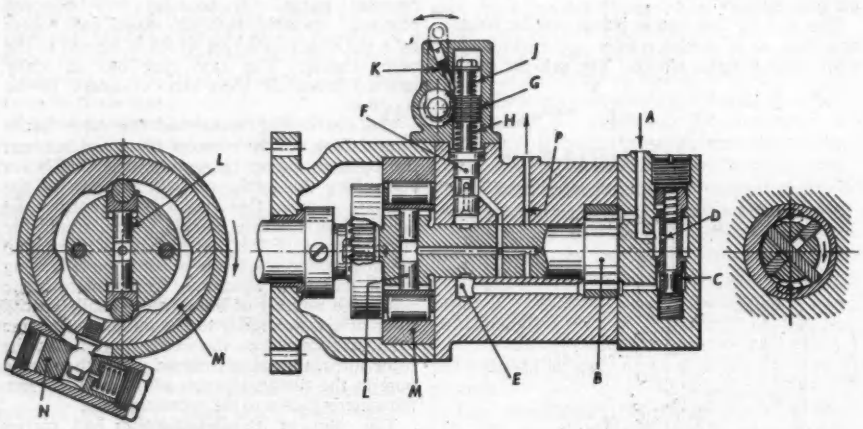


Fig. 3—Sectioned pump mounted on four-cylinder engine



A—Fuel inlet.
B—Transfer pump
C—Priming port.
D—Regulating port.
E—Transfer gallery.
F—Metering valve.
G—Control rack.
H—Governor spring.
J—Idling spring.
K—Idling stop.
L—Pump plungers.
M—Cam ring.
N—Automatic advance.
P—Outlet passage.

Fig. 2—Simplified section through the distributor fuel pump

Continuous Casting of Steel Billets

We are informed by the United Steel Companies, Ltd., that mild steel billets of commercial quality are now being produced in a pilot continuous casting plant at the Barrow Steel Works, Ltd., on a Rossi-Junghans machine. Extensive development work has been carried out over the past three years on this machine and it is operating at speeds of over 200in per minute, producing the equivalent of 7 tons of 2in square steel billets per hour.

Steels for continuous casting are melted and refined in a 5-ton electric arc furnace which serves the plant. Ladles of molten metal from this furnace are teemed into a tundish at the top of the continuous casting plant, and the steel then flows at a controlled rate into a reciprocating water-cooled copper mould. A partly solidified billet—its central core is still liquid—is withdrawn from the bottom of the mould and solidification is completed as the billet travels vertically down the machine. When it emerges in solid form at the bottom of the machine, the continuously cast billet is cut to the required lengths.

The pilot plant at Barrow is capable of producing billets from 2in to 4in square and slabs of up to 6in by 2in in cross-section. Satisfactory results are stated to have been obtained in the continuous casting of mild steels, low alloy steels and stainless steel. In subsequent manipulation it had been found that the continuously cast carbon steels have good forging characteristics, while high-quality sheets have been rolled from continuously cast stainless slabs. The company states that experiments are continuing with a view to establishing a satisfactory process which will be both economic and repetitive.

Aviation Fuel Filters.—Filters capable of straining aircraft fuel at the rate at which it is pumped into the aircraft dissipate a great deal of power, and to conduct full-scale tests of such filters the British Petroleum Company has now installed a test rig at its laboratory at Sunbury-on-Thames. Kerosene is stored in two 1000-gallon stainless steel tanks and circulated through tubes of glass or tinned steel by a Pegson centrifugal pump giving flow rates up to 260 Imperial gallons per minute. Random contamination is removed from the fuel by circulating through an auxiliary filter, and a measured quantity of artificial contaminant is dispersed into the fuel. When the filter is under test, flow and pressure drop measurements can be made, and samples of feed and filtrate taken. Water separators can be tested in a similar way.

Automatic Triple-Draw, High-Speed Drawbench

As part of the extensive programme of expansion and modernisation which has been in progress for some time at the Kitts Green, Birmingham, works of James Booth and Co., Ltd., an interesting new automatic triple-draw, high-speed, drawbench for the production of aluminium alloy tubes was recently installed. The machine was supplied by the Head Wrightson Machine Company, Ltd., Middlesbrough, and is designed to draw tubes up to 130ft long. It is capable of exerting an effective pull of 60,000 lb, and can draw three tubes at a time up to 2in diameter, or single tubes up to 3in diameter, at draw speeds up to 450ft per minute.

Rotating backbench end of automatic triple-draw drawbench. At the end of each drawing cycle the backbench rotates through 180 deg. to align three undrawn tubes with the dies

In the automatic operating cycle of the machine three undrawn tubes are first removed from a stack and fed over three plug rods in the backbench, while three tubes previously loaded are being drawn. On completion of the draw the backbench is rotated to bring the undrawn tubes into line with the dies, and the plugs on which they are mounted are moved forwards until the tube-tags protrude through the dies. During this movement the drawn tubes are ejected and the draw carriage is then returned to the die stand to grip and commence drawing the previously loaded tubes. Simultaneously, the next three tubes are fed over the other set of plug rods ready for the following cycle. This method of loading tubes whilst others are being drawn, combined with the high-speed operation, ensures maximum machine utilisation.

The general arrangement of the new machine can be seen in the photograph we reproduce above. It has an overall length of just over 270ft and is designed for continuous operation under the control of one man situated at a desk by the die stand between the backbench and the drawbench of the machine. The backbench, in the foreground of the illustration, is some 110ft long and takes tubes up to 105ft long before drawing. The drawbench, with a length of 160ft, gives the maximum length of draw of 130ft.

At the draw end of the machine the tubes to be drawn are loaded by an overhead crane into the stacking pockets of a magazine built of structural steel and situated above the level of, and adjacent to, the rear of the main drawbench bed. These stacking pockets are supported on an elevating mechanism driven through reduction gearing by two 5 h.p. motors. At the beginning of a cycle these pockets are raised and a kick-out device, actuated by a pneumatic cylinder, kicks the tubes over, one at a time, into a trough in line with the top set of plug rods of the backbench. A pusher gear driven by a 7½ h.p. motor then comes into operation to push the three tubes in the trough over the drawing plugs, which are mounted on the ends of 100ft long rods in the backbench. The tubes are pushed on the rods at a speed of 350ft per minute. Alternatively, a set of pinch rolls driven by a 3 h.p. motor can be used to feed lighter tubes, which would bend if pushed from the rear, over the plugs at a speed of 440ft per minute. When required this pinch roll equipment is mounted immediately in front of the plugs and its rolls are opened and closed through a system of links by a pneumatic cylinder in the base of the assembly.

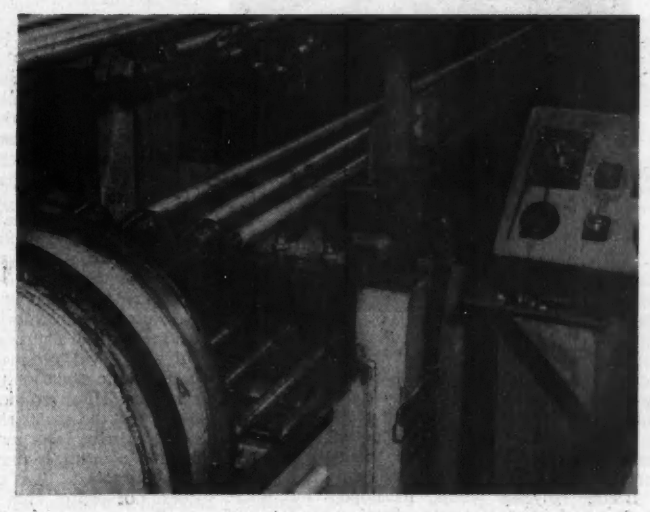
Two sets of three plug rods at 6in centres are positioned one above the other in the backbench, and each rod is provided with means of individual adjustment at the anchorage end, so that each plug can be positioned relative to its die. The backbench is arranged for rotation by a rack and pinion operated by a pneumatic cylinder to bring the sets of plug rods in turn into line with the drawing dies. Thus, whilst one set of rods at the upper position in the backbench is being charged with tubes the three tubes in the lower position are being drawn. On completion of the draw the backbench is rotated through 180 deg. to bring the three undrawn tubes into line with the dies. At the conclusion of the turning movement a 22in stroke, double-acting air cylinder at the rear of the plug rod backplate moves the lower set of rods forwards until the tube tags protrude through the dies a sufficient distance to engage with the draw carriage grips and the plugs are correctly positioned in respect to the dies. Hollow plug rods are used on the machine and a supply of oil is pumped into their bores through flexible pipes at the rear to ensure an effective flow of lubricant to the insides of the tubes as they are being drawn.

A triple-draw dieplate used to hold the dies in place is fitted with special holders designed to facilitate rapid alignment of the dies after changing from one size to another. This plate can quickly be removed and replaced with a single draw dieplate when it is required to draw tubes of more than 2in diameter and the dies themselves can be changed without removing the dieplate. The plates incorporate a system of oil sprays which provide an adequate flow of lubricant on each die during drawing.

When the backbench has been rotated and the tags of a fresh set of tubes are in position through the dies, the draw carriage of the machine is brought up to the die stand by a high-speed winch gear. This return winch is driven by a two-speed 6/2 h.p., 1500/500 r.p.m. motor, giving a carriage return speed of 600ft per minute and an inching speed of 200ft per minute. As the carriage nears the die face on its return movement its speed is automatically reduced until it comes gently into contact with the die stand. At this point adjustable tappets projecting from the face of the carriage are pushed backwards to operate a mechanism which moves the gripper jaws into engagement with the tube tags and lower the carriage hook into contact with the main chain ready for the drawing operation to commence.

The draw carriage mounted on a heavy bed below the tube loading trough, is driven through a chain by a 500 h.p. motor and gearing, giving a range of drawing speeds from zero up to 225ft per minute at 60,000 lb pull, and to 450ft per minute at 30,000 lb pull. This variable speed drive enables the machine to be set for a slow speed at the commencement of draw followed by rapid acceleration from the preset bottom speed up to the required top speed. The arrangement also eliminates shock loading as draw starts, and it enables greater reductions to be made on tubes than would otherwise be possible.

An inching control is provided so that the carriage can be moved along the bed at slow speeds. In the event of a tube breaking whilst being drawn, this inching control enables the carriage to be repositioned accurately to re-engage



Dieplate from the control platform of the drawbench. The top set of three tubes are ready for loading on to the plug rods. The lower set of three tubes have been entered in the dies ready for drawing

its gripper jaws and complete the draw. A series of skid arms set at intervals along the drawbench bed swings into place as draw progresses to support the tubes. On the completion of a draw the tubes are automatically released by the gripper jaws and they gravitate off the skid arms on to an inclined stacking rack adjacent to the machine and on the opposite side to the undrawn tube stacking pockets.

From his platform at the side of the die stand the operator has a clear unobstructed view of all operations, and is able to maintain full control through the switches on the control panels situated within easy reach at the side and rear of the platform. One of our illustrations shows the control platform and the head of the drawbench with the loading trough above. In it there can be seen three tubes ready for loading on the plugs with, in the lower position, three tubes just entering the dies.

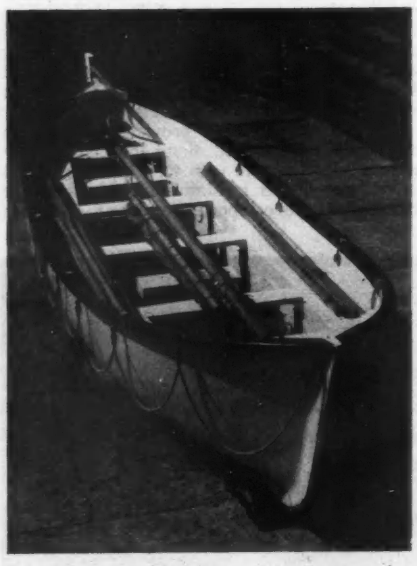
The drawbench end of the machine extends into a recent addition to the main tube shop of the works. In this extension, which is some 125ft wide and 170ft long, there has also been installed a new 50ft long continuous roller hearth electric heat-treatment furnace for the alloy tubes. A 6-ton overhead crane of light alloy construction, which serves the shop, is supplied with special beams, also of light alloy construction, for handling packs of long tubes between the new machine and the storage racks.

Glass-Reinforced Plastic Lifeboat

WOOD as the traditional boat building material has been challenged, particularly in the post-war years, by steel and aluminium alloys and more recently by plastics. The latest addition to the ranks of plastic boat builders is Woodnutt and Co., Ltd., St. Helens, Isle of Wight, and last week we were able to inspect a 24ft ship's lifeboat, illustrated herewith, which has been designed and developed by the plastics division of the company, a company which has been building yachts and cruisers since the middle of the last century. The inception of the division dates from October of last year, when the company was taken over by J. Stone and Co. (Holdings), Ltd., and the intervening months have been ones of constant experiment to produce a suitable plastic and a method of construction.

TABLE I—*Comparative Strengths of Materials*

Specimen	Weight, pounds	Thickness, inches	Breaking load, pounds	Maximum deflection, inches	"E" ÷ 10⁶, pounds	Tensile strength (tons per square inch)	Impact strength (pounds per square inch)
F.R.P. laminate	5·8	0·233	5260	1·77	1·48	7	20
Aluminium alloy	4·3	0·101	1300	1·3	10	14	20
Mild steel plate	9·5	0·075	1750	1·1	29	28	45



24ft glass-reinforced plastic lifeboat

Research into the problem of a suitable material has resulted in the formulation of a plastic known as F.R.P., which is basically a Beetle Polyester resin, developed by B.I.P. Chemicals, Ltd., into the chemical structure of which fire-resisting chemicals have been linked during manufacture but which does not contain additives which may leach out in course of time. These polyester resins form the raw material which is considered to possess most of the advantages of wood, steel and aluminium alloys for boat building. The unsaturated resins are colourless viscous fluids which become rigid when certain additives, including an accelerator and a catalyst, are introduced and attain the necessary strength with the introduction of mats of chopped glass fibre, manufactured by Fibreglass, Ltd., when the specially treated resin is in a tacky condition.

The resultant material is easy to cast or mould with unskilled labour and possesses considerable structural strength. This can be seen from the accompanying table, which represents the results of applying a load to the centre of freely supported panels measuring 3ft by 1ft.

Since the material is chemically inert it is impervious to corrosion and to both dry and wet rot. It is also immune from the attacks of marine borers and resistant to sub-aqueous growths which, if they should occur, can be wiped off. Again, the material is almost entirely non-absorbent, and tests carried out by the Department of Engineering, Southampton Technical College showed that the average gain in weight of F.R.P. panels immersed for eighty-four days in fresh water was 0·57 per cent — 0·74 per cent in salt water. Immersion in hydrochloric acid resulted in slight surface discoloration, while sulphuric acid produced no noticeable effect, and caustic soda only slightly roughened the surface. However, immersion in nitric acid destroyed the material by delamination. Any colour can be incorporated during manufacture so that painting is unnecessary, although paint can be applied. It is claimed that the material does not warp and that shrinkage is very small, so that a hull made of F.R.P. will closely conform to the original lines plan.

Other characteristics believed to be possessed by F.R.P. are that it is stable and unaffected by humidity and changes of temperature, resilient and of high impact strength, and self-extinguishing. The degree of resistance to fire is shown in the following table, which gives the results of laboratory flame spread tests.

TABLE II—*Flame Spread Tests*

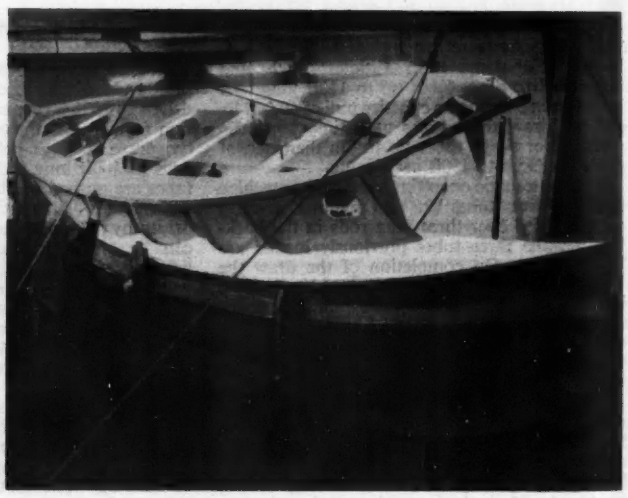
Material	Time required to ignite, seconds	Time required to extinguish, seconds	Total distance burnt, inches	Flame spread in seconds, 1in, 2in, 3in, 4in
¼in elm board...	7	445	6½	10, 23, 40, 80
¼in mahogany board	20	223	7½	20, 25, 37, 55
Glass-reinforced laminate of Beetle resin 4128, plus 15 per cent Cereclor, plus 5 per cent Ant. Trioxide, plus 4 per cent white pigment	45	665	4½	50, 90, 170 240
F.R.P. laminate (white)	73	207	1½ (charred)	75

It is considered by the builders that the properties of the building material, as enumerated above, mean that maintenance costs will be reduced to the minimum.

The boat on display conforms with the requirements of the Board of Trade specifications and has the following particulars :

Length	24ft
Breadth...	8ft
Depth	3·3ft
Weight, including fixed fittings	24 cwt
Davit weight	33 cwt
Capacity	42 persons

To construct the lifeboat, a faired and wax-polished male pattern treated with a parting agent is prepared and the surface treated with a parting agent before starting to build up the female mould. First a coat of resin is applied, followed by a fine glass cloth wetted with resin which is rolled in with steel split washer hand rollers. A mat of chopped glass strands is laid on next, then impregnated with resin and rolled, and this procedure is repeated with the mat layer until all the air has been worked out from the glass mats and the necessary thickness to give the required strength has been attained. After curing, the female mould is removed and the internal surface is well polished ready for the shell of the boat to be laid up inside it. This is done by the same method as that employed in making the mould.



Internal structure ready for placing inside uncured hull

Ancillary interlocking moulds have been made so that the internal structure of the boat, including buoyancy tank divisions and thwarts, can be made in one piece, as shown in our illustration, ready to be pressed into position, while the hull is still wet and uncured, and so welded in place. By this means the two main structures are completely integrated to form a boat of monolithic construction. For the keel, also of F.R.P.,

a special lightweight form of construction incorporating watertight subdivision has been evolved, and tests have indicated its strength.

In July the lifeboat successfully passed the official tests, including manœuvrability, being dropped from a height of 8ft into the water, and four strength tests. In No. 1 test the boat was lifted fully equipped plus 25 per cent overload, and in test No. 2 the fully equipped boat plus 50 per cent overload rested on blocks placed under the lifting hook positions. The same procedure was followed in the next two tests, but the overload was increased to 75 and 100 per cent respectively. Upon examination after the tests no permanent set or signs of straining were observed and the buoyancy tanks remained tight. Table III gives a record of the strain measurements taken.

TABLE III

Test No.	Keel sag, inches	Gunwale drop, inches	Gunwale spread, inches
1			
2			
3			
4			

Langstone Bridge, Hampshire

LANGSTONE BRIDGE, which connects Hayling Island with the mainland, is one of the few remaining important toll bridges in the country, and was originally built in 1824. A prestressed and reinforced concrete bridge, designed for full Ministry of Transport loading, has now been built to replace the old wooden bridge, and was inaugurated by the Joint Parliamentary Secretary, Ministry of Transport, Mr. Molson, on Monday, September 10th. The new bridge is illustrated herewith; it is 958ft long and the approaches are 2542ft long, making a total length of 3500ft. The height at the centre is +18·46ft O.D. The overall width is 34ft and there will be a single carriageway 22ft wide with two 5ft wide footpaths.

The design of the approach embankments at either end of the bridge is based upon recommendations from the Road Research Laboratory. The base consists of quarry waste 1ft thick, with layers of consolidated hard filling above it. Toe protection is provided by prestressed concrete sheet piling, and protection against tidal water by clay puddle and concrete blocks 1ft by 2ft by 6in deep, sealed with bitumen. The side slopes of the embankments are generally 1 in 1½, except for the eastern slope of the north embankments, which is 1 in 6 to provide mooring facilities.

The multi-span bridge consists of a deck of prestressed beams carried on a series of reinforced concrete pile bents, which are driven down to the hard chalk underlying the mud, chalk rubble and flint of the channel. There are in all thirty-three spans—twenty-nine of 30ft and four of 7ft, the latter placed at approximately the fifth points. Each of the thirty-four pile bents supporting these spans consists of five precast reinforced concrete piles, arranged in line across the width of the bridge, carrying an *in situ* reinforced concrete capping beam.

The piles, 170 in all, are 1ft 4in square in section; in each bent the outer pair have a rake of 1 in 10, the inner pair have a rake of 1 in 20, and the central one is vertical. Lateral sway forces are taken by the raking piles, and north-south sway forces are restricted by the four double-pile trestles at the fifth points. The length of the piles for the first half of the bridge was determined by driving test piles of up to 80ft in length; for the second half, data obtained in driving the contractor's temporary timber staging piles was also used to assess the length of piles required. The beam supported by the piles is 1ft 6in deep and 2ft 2in wide and carries the sixteen precast prestressed concrete deck beams and the two parapet beams which make up the deck in each span.

The deck beams are 1ft 6in square in section, with slightly inclined sides to permit caulking mortar to be packed between them in the narrow "V"-joint. They are individually post-tensioned in the longitudinal direction with two 1¼in diameter "Macalloy" bars. Transversely they are stressed together on the Freyssinet system, to create a monolithic slab. Twenty-four of the beams have been tested on site to 250 lb per square inch tension and have shown no defect; a further two beams are being tested at the Cement and Concrete Association's research station to determine creep losses and ultimate strength.

Between the slabs there are expansion joints consisting of bitumen and bituminised felt. The south end of each slab is fixed to the pile cap by rustless steel dowel bars but the north end is free to move over a piece of bituminised felt laid on top of the pile cap. A space has been left between the beams containing the anchorage of the transverse prestressing and the parapet beams; this provides a duct for services running the full length of each side of the bridge. Footpaths are cast *in situ* between the anchorage beams and the parapet beams, over these ducts.

The parapet beams are also prestressed and are separated by expansion joints containing compressed rubber sheeting. They are surmounted by a cast stone coping. The handrails are 3ft 4in high, of 1¼in bore metal tubing, treated with a coating of flame-sprayed zinc and painted with zinc chromate primer and chlorinated rubber undercoating and finishing paint.

All the piles and prestressed concrete beams were precast on the site, and casting beds were set up on the mainland for twenty 80ft piles and thirty-six beams. The concrete for the prestressed deck beams has a specified cube strength of 6000 lb per square inch at the time of stressing; that for the piles of 6000 lb per square inch at seven days. The capping beams and footpath slabs have a specified cube strength of 2450 lb per square inch at seven days. A 1 : 3 mix with a water/cement ratio of 0·3 was used, and compacted by internal vibration in the moulds. The piles and beams were handled by a 7½-ton gantry in the casting yard and transported to the bridge by a diesel locomotive running on a narrow gauge railway.

In construction, work proceeded from the mainland towards the island; timber staging was driven in advance of the concrete piling by a cantilever pile frame with a drop hammer. The 80-ton frame for driving the concrete piles moved along the staging; this frame was 100ft high and fully power-operated; steam from boilers of 30 h.p. capacity drove a three-drum winch and single-acting 6-ton hammer. The foundations for the embankments were excavated by a 6in pump with a hydraulic cutter mounted on a small crane barge; this was supplemented by a dragline working from the old causeway. In all, 5500 cubic yards of fill were used for the embankments, and the bridge required 2500 cubic yards of concrete and 350 tons of steel.

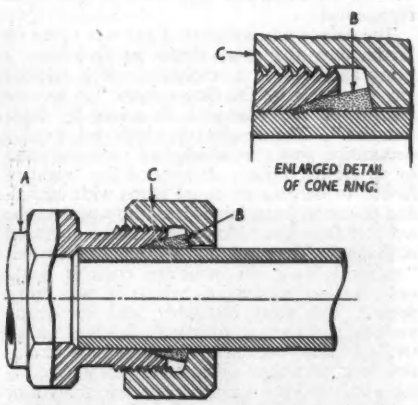
The bridge was designed by the Hampshire County Council's surveyor's department, under the direction of the county surveyor, Brigadier A. C. Hughes. The main contractor was Christiani and Nielsen, Ltd.

Eastern face of the new Langstone bridge from the mainland

Hydraulic Pipe Coupling

A RANGE of high-pressure pipe fittings for use in hydraulic piping systems is now being manufactured under the trade name "Supakone" by Kay and Co. (Engineers), Ltd., Blackhorse Street, Bolton, Lancs. These fittings are stated to be suitable for working pressures of 10,000 lb per square inch and are made in a number of sizes in straight and stud couplings and tees and elbows.

The method by which a joint is made when coupling the fitting to a pipe can be seen in the drawing we reproduce. The three main components—the body *A*, the cone ring *B* and the coupling nut *C*—are made from steel bar and forgings. When fitting a coupling the squared end of the tube is pushed into the bore of the body up to the stop face, the cone ring is inserted and the nut tightened on it. When the nut is tightened the nose of the cone, which is made of heat-treated steel, is forced against a tapered annular seating in the rear of the body bore. This first causes the end of the cone to curl slightly and close down on the tube. Further tightening of the nut forces the leading edge of the cone into the surface of the tube, and the inward sliding movement of the cone raises a burr which eventually fills the annular space between the cone and the body. At this point the cutting action ceases and the tube is locked in position with a rigid leakproof joint.



Arrangement of coupling on a pipe. Tightening the coupling nut forces the nose of the cone ring on to the tube and raises an annular sealing burr when the joint is fully locked

The makers state that this design of coupling can be dismantled and reassembled any number of times provided the same sets of parts are used.

Industrial and Labour Notes

The Trades Union Congress

Brief reference has already been made in these notes to the debates at the Trades Union Congress which continued throughout last week at Brighton. The resolutions of special importance passed by the Congress were those concerned with automation, wages policy and the forty-hour week.

The subject of automation was debated on Tuesday of last week. There were two composite resolutions on the matter, the first of which was endorsed by the T.U.C. general council. This resolution, which was carried by a large majority, said that the T.U.C. was not opposed to automation developments which were "recognised as inevitable." It went on to declare that the interests of trade union members must be safeguarded "against any ruthless application of automation by employers," and that the wages and conditions of workers in occupations not easily converted to automatic processes must not lag behind those in manufacturing industry. The resolution then stated that where automation was to be applied or contemplated it was essential that discussion between the employer and the employees' representatives should take place. Moreover, the resolution added, in such discussion it must be the responsibility of the unions to ensure that the fullest consideration be given to recruitment and training policies and the avoidance of redundancy, the maintenance of the level of earnings and reduction in the price of the commodities produced, and that where labour was displaced adequate maintenance should be paid. The second resolution, which was not carried, called upon the T.U.C. to affirm that only by national planning could the introduction of automation and nuclear power provide the maximum benefit for all people. In view of "the Government's negative and muddled attitude on the matter," the resolution advocated that the T.U.C. general council should ask the Prime Minister to set up, without delay, a permanent commission or national planning board for automation, under the control of a responsible Minister, on which the T.U.C., the employers, and scientists should be represented.

The debate on economic affairs was taken on Wednesday, the most significant factor in it being approval of a resolution which rejected any proposals by the Government "to recover control of the economic situation by wage restraint." The resolution which led to this declaration was one which had been endorsed by all the big unions. It asserted the "right of labour to bargain on equal terms with capital, and to use its bargaining strength to protect the workers from the dislocations of an unplanned economy." The resolution also emphasised that "major reliance on monetary controls could not increase production where it was most needed, but must inevitably lead to erratic markets and damage over wide fields of industry." In this "menacing situation," the resolution declared, technological developments (including automation) must aggravate unemployment unless there was re-established the foundations of a planned economy.

The resolution on the working week was brought forward on the last day of the Congress, Friday. It confirmed the T.U.C.'s support for the forty-hour week and expressed the view that the time was now opportune to achieve it. The resolution pledged the T.U.C. to "support efforts by affiliated organisations tending to shorten the working week." The resolution was carried, although the T.U.C. general council did not approve the form in which it had been put forward.

Employment and Unemployment

The Ministry of Labour has reported that at the end of July the number of people in civil employment in Great Britain was 23,042,000 (15,253,000 men and 7,789,000 women), which was 11,000 more than a month earlier, and 66,000 more than at the end of July, 1955. The increase in employment in July this year was mainly seasonal as it occurred in miscellaneous services like catering and the distributive trades.

An analysis of the July employment figures shows that there were 4,016,000 at work in the basic industries. There were additions to the numbers employed in agriculture and transport, but mining manpower dropped a little, and at the end of July there were 702,000 wage earners on colliery books. In the manufacturing industries, the number at work in July was 9,212,000, indicating a decrease of 22,000 during the month. There was an addition to the number employed in the manufacture of food and drink, but in most of the other manufacturing groups there were fewer people at work. In vehicle building, manpower fell by 11,000 to a total of1,226,000, compared with 1,230,000 a year earlier. In the engineering industries also the number employed fell by 11,000 to 2,789,000, which, however, was 24,000 more than in July last year. In other industries and services, the Ministry reports a fall of 10,000 in the number at work in building and contracting, making the total at the end of July 1,505,000, compared with 1,489,000 a year earlier.

About unemployment, the Ministry's report states that on August 13th the number of people registered as out of work was 266,541, compared with 238,137 on July 16th. The August unemployment figure included 48,000 who were temporarily stopped and 15,000 boys and girls who were registering for work after leaving school. Unemployment in August was 1·2 per cent of the estimated number of employees; the comparable figure for last year was 0·9 per cent.

Mining Industry's Summer School

This week the National Coal Board has been holding its tenth annual summer school, at Oxford. It is being attended by about 500 students, representing all sections of the coal industry and including eighty colliery workers.

The opening address last Saturday was delivered by Mr. James Bowman, chairman of the National Coal Board, and on Monday, the deputy chairman of the Board, Mr. J. Latham, gave a lecture to the school. He said that the coal mining industry was at a disadvantage in recruiting men when there were other industries which could offer easier working conditions. In this, Mr. Latham urged, there was a challenge to develop new machinery and methods of doing things which would not only save manpower but would create better working conditions in the mines. Mr. A. Walsh, the Coal Board's industrial relations director, who also spoke on Monday, pointed out that manpower wastage in the coal mines was heaviest in the most productive age groups, those between twenty-one and forty-one. Last year, he said, nearly 67,000 men had left the mines, and in an attempt to counteract so serious a position, the Board has appointed officers to find out exactly why men left, so that its policies could be adjusted accordingly.

Estimates of Capital Expenditure

At the end of June, the 600 companies which contribute to the Board of Trade's regular sample inquiry into fixed capital expenditure were asked for a provisional estimate of their expected expenditure during 1957. The Board of Trade says that returns have now been received from about two-thirds of the companies approached. The estimates prepared from the information suggest that companies in manufacturing and in other industries, excluding shipping, are at present expecting to spend in 1957 a little less than they expect to spend this year. Companies in the shipping industry are expecting to spend about 5 per cent more.

The estimates for manufacturing industry show a decrease of 1 per cent in total expenditure in 1957 compared with anticipated expenditure this year, an increase of 1 per cent in expenditure on plant, machinery and vehicles being balanced by a decrease of 9 per cent in expenditure on building work. Companies operating in the chemical and allied trades and in the metal manufacturing trades show increases, but those in other industry groups indicate few changes or decreases. Expenditure of shipping companies is expected to increase by about 5 per cent between this year and next. This, it is suggested, is due to forecasts of large increases by tanker-owning companies, the forecasts of other shipping companies showing decreases.

But the Board of Trade points out that, although companies have been able to give a provisional indication of their expenditure during 1957, it must be realised that most companies do not normally settle their plans for future expenditure so early in the year. The forecasts upon which the estimates of changes between 1956 and 1957 are based must, therefore, be taken as "very provisional," and to contain a much larger degree of uncertainty than those which are given to the Board of Trade each autumn as part of the regular pattern of the inquiry.

Old Skills in New Settings

The problem of using established skills in new or altered industrial situations is discussed, in the current issue of *Occupational Psychology*, by Mr. E. G. Chambers, of the Medical Research Council's Applied Psychology Unit. Mr. Chambers says that there have been many experiments which have made valuable contributions to the theory of learning, but the practical problem of transfer of training has remained relatively untouched.

But, Mr. Chambers emphasises, it is a problem which is becoming increasingly important. Older workers are being retained after the traditional retiring age and, as it is unlikely that most of them can continue to work in the same jobs, it is essential to know to what kind of occupation they can profitably be transferred. New machines, making new demands on human beings, are constantly being invented, the article continues, and raise the question whether new kinds of workers must be trained to man them, or whether trained workers can be recruited from other occupations. Automation, Mr. Chambers remarks, will make workers redundant, and the problem of their re-employment will be urgent.

Mr. Chambers then says that though he does not want to decry the value of the laboratory experiments on training, they do not seem to be very helpful in solving these practical problems. Learning to do a test to a certain "criterion" in a few sessions, he asserts, is not the same at all as acquiring industrial skill over years of practice. Few, if any, operatives in industry, Mr. Chambers comments, need to learn words in paired association or press one of six buttons when a green light appears at the apex of a triangle! What no one seems to know, Mr. Chambers says, is how far proficiency in such artificial situations can be carried over to the real jobs done by workers in different occupations. Mr. Chambers thinks that the time is more than ripe for a determined attack to be made on the problem.

Restrictive Trade Practices Act

The Federation of British Industries has published a booklet entitled *Restrictive Trade Practices Act, 1956—a Guide for the Industrialist*. The preface points out that "for the first time Parliament has expressed through the new Act a general disapproval of restrictive practices on the management side of industry and commerce." The purpose of this booklet is to enable industrialists and trade association officials to see whether they are likely to be affected, and if so to take legal advice. It is emphasised that the "last word" in each case will rest with the new Restrictive Practices Court. The provisions of the Act are summarised in eight chapters and there are chapters dealing with the enforcement of resale price maintenance and with the functions of the reconstituted Monopolies Commission. The price of the booklet is 4s.

Glockner-Kaprun Hydro-Electric Scheme

No. I

A major hydro-electric scheme in the Austrian Alps is described. It is a two-stage development with two seasonal reservoirs which permit about three-quarters of the net power output of 615 million kWh annually to be generated in the winter. The total installed capacity is 312MW: pumping plant is also installed for additional peak load generation.

AUSTRIA is at present engaged on an extensive programme of power station construction. The bulk of this programme is hydro-electric, since the country abounds in favourable sites for water power development. In fact, the rivers of the Austrian Alps offer potentialities as favourable as can be found in Italy, Switzerland and France, but relatively few schemes have been built compared with these other countries. The rate of consumption of electrical power has not, in the past, grown so rapidly in Austria and consequently there has been less encouragement to raise the large capital sums which such construction requires, and development has not proceeded at such a feverish rate. But the relative abundance of good, undeveloped hydro-electric sites in Austria led to the idea that the country's water power resources should be developed for export. So, within the past few years activity has increased and sites are being developed as fast as the country's economy permits. Existing hydro-electric stations provide about three-quarters of the total quantity of electrical power consumed annually in Austria, as can be seen from the figures in Table I. Although development has been on a smaller scale, nationally, than in the neighbouring countries of Western Europe, technically it is in general equally advanced and has been on a scale sufficient to allow the establishment of a school of design as characteristically national as those of each of the countries named above.

TABLE I—*Austrian Electrical Power Statistics*

	Production in kWh × 10⁶	
	1954	1955
Hydro-electric :		
Run-of-river stations	4,825	5,217
Stations with reservoirs	2,433	2,687
Total	7,258	7,904
Thermal-electric :	2,589	2,847
Total electricity production	9,487	10,751
Import (+)	272	446
Export (−)	1,492	1,498
Consumption, including losses	8,627	9,699

Estimated total national resources of hydro-electric power, kWh × 10⁶	40,000
Amount developed by 1956, kWh × 10⁶	8,000
Amount under construction, kWh × 10⁶	3,000
Installed capacity in 1956 :	
Hydro-electric power stations under construction or in operation, MW	2,800
Thermal-electric power stations, MW...	870

The largest of the run-of-river schemes in Austria—at Ybbs-Persenbeug on the Danube—was described in these columns quite recently. The second class of schemes—those in high alpine catchments—can be represented by the largest amongst them, at Glockner-Kaprun, which has formed a major part of the Austrian constructional programme since the war. The importance of winter power again emerges as a critical factor in this scheme. The comparatively small total capacity of the reservoirs of Austrian schemes is indicated by Table I, which shows that about two-thirds of the total hydro-electric generation is from run-of-river stations. Thus, substantial reservoirs for seasonal storage form an important part of the scheme; they are supplemented by the installation of pumping sets, which are intended to meet peak loads on a short-period basis.

The Glockner-Kaprun scheme is situated in the High Tauern mountains. Kaprun, where the main power station at the "base" of the scheme is built, is only a few miles from Zell-am-See, and the diversion tunnels taking water to the scheme extend to an intake on the Leiter River, south of the Grossglockner. The main river of the scheme—Kapruner Ache—is a tributary of the Salzach. Construction was started in 1938, but most of the main works are much more recent. Design work is in the hands of the company which holds hydro-electric concessions in the High Tauern mountains, Tauernkraftwerke A.G., whose head office is at Salzburg.

The company has planned in outline several major schemes in the High Tauern valleys to the west of the catchments of the Glockner-Kaprun scheme. One of these projects (Matrei) is even larger than the Glockner-Kaprun with a capacity of 380MW, and there are three others each with capacities of about 200MW. These schemes develop an area for which, in 1928, German engineers had planned a vast project (A.E.G.'s Munch project) with high level aqueducts at about 2200m and totalling 1200km in length, connecting a vast area to reservoirs in the Kaprun valley, with three stages of power stations below. The three reservoirs of this scheme would have given a storage equivalent to 1400 million kWh, and a total production of 6600 million kWh, 35 per cent of it in winter. The present schemes, however, give a higher yield of winter power.

The Tauernkraftwerke is now also constructing a scheme below the Glockner-Kaprun catchment at Swarzach, on the Salzach River. This scheme will utilise the regulated flow from the Kaprun catchment, and the unregulated flow of the Salzach itself, in a run-of-river development of 120MW installed capacity and 395 million kWh output, 41 per cent of the output being in winter. This scheme is designed for a flow of 100 cumecs and a head of 149m. It will be followed by a second stage of 85MW capacity and three subsequent stages are being designed by the company to complete the utilisation of the Salzach from its junction with the Kaprun River down to Salzburg.

THE GLOCKNER-KAPRUN WORKS

The scheme now substantially completed at Glockner-Kaprun has many points common to all large-scale developments which have, up to the present, been built in the highest alpine catchments. A principal aim is to store the heavy run-off of late spring and summer, in seasonal reservoirs sited as high as possible. Fig. 1 shows the principal reservoirs.

The completed scheme will generate about

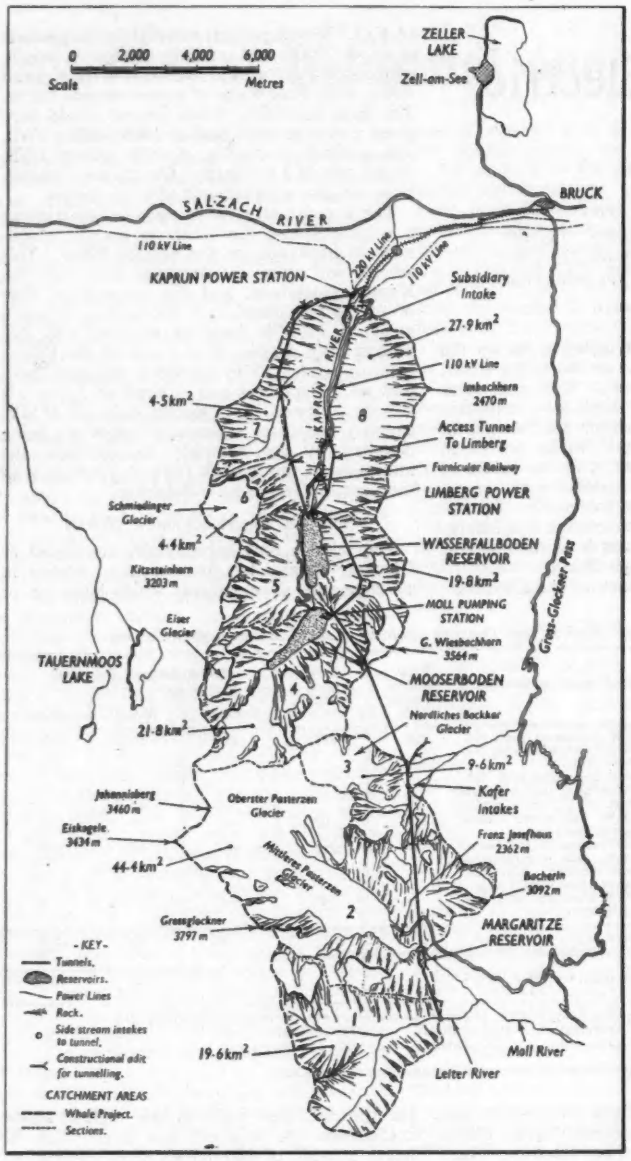
TABLE II—*Power Stations and Pumping Stations of the Glockner-Kaprun Scheme*

	Details of machines installed	Total installed capacity, MW	Gross head, metres	Power output, kWh × 10⁶		
				Summer	Winter	Total
Kaprun	2×45MW horizontal shaft Pelton wheel sets, each with two turbines	200	891	80	385	465
	2×55MW horizontal shaft Pelton wheel sets, each with two turbines					
	2×0·27kW horizontal shaft Francis auxiliary sets	0·52	65	—	—	—
Limberg	2×56MW horizontal shaft pumping sets, each comprising a Francis turbine, generator/motor and centrifugal pump	112	363	66	84	150
Möll Pumping Station ...	2×6·7MW horizontal shaft centrifugal pumps	—	80	—	—	—
	Net annual output			146	469	615
	Annual pumped-storage output for peak load generation ...			—	—	200
	Gross power generated annually			—	—	815

NOTE.—Total installed generating capacity is 312MW. Hours of operation for net power outputs given above are :
Main stage ... ... 400 (summer) ... 1925 (winter) ... 2325 (total)
Upper stage ... ... 589 (summer) ... 750 (winter) ... 1339 (total)

Off-peak pumping and the consequent peak-load generation are in addition to these totals.

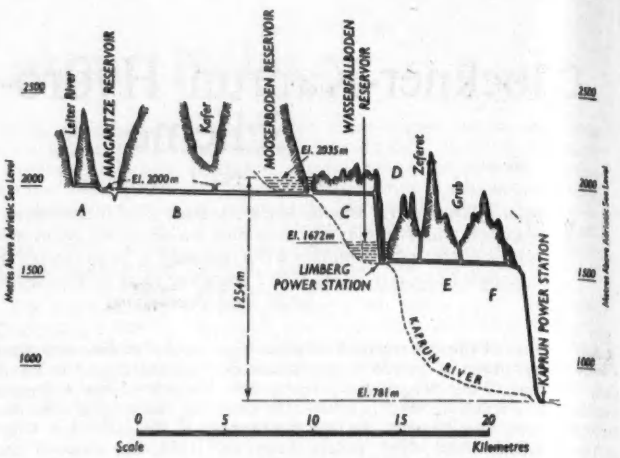
Fig. 1—The two seasonal reservoirs of the Glockner-Kaprun scheme, which develops catchments in the Salzburg and South Tyrol districts of Austria. Mooserboden reservoir is in the foreground, with Wasserfallboden and the crest of Limberg dam visible lower down the valley



Catchment areas :

	Sq km		Sq km
1—Leiter	19·6	5—Kaprun catchment between Mooserboden and Wasserfallboden	19·8
2—Möll	44·4	6—Zeferet	4·4
3—Käfer	9·6	7—Grub	4·5
4—Kaprun catchment above Mooserboden...	21·8	8—Lower Kaprun (serving auxiliary intake)	27·9

Fig. 2—The Glockner-Kaprun scheme



Tunnels of the scheme

A—Free-flow tunnel from Leiter river intake to Margaritze reservoir, length 1·8km, diameter 2m.
B—Möll diversion tunnel. Concrete-lined, horseshoe tunnel, length 11·6km, equivalent diameter 2·9m to 3·4m ; capacity 20 cumecs ; subsidiary intake on Käfer river.
C—Main tunnel from Mooserboden to Wasserfallboden. Concrete-lined, circular tunnel ; length 4·5km, diameter 3·3m.
D—Pressure shaft, with surge shaft and chamber above. Length of shaft 670m, diameter 2·5m to 2·9m ; capacity 36 cumecs.
E—Tunnel from Wasserfallboden to Kaprun. Concrete-lined, circular tunnel. Length 7·1km, diameter 3·2m to 3·3m ; capacity 32 cumecs ; side-stream intakes from Zeferet and Grub rivers.
F—Maiskogel surge shaft and tank, and penstocks to Kaprun power-house. Four lines of steel pipes. Length 1200m, diameter 1·25m to 1·15m.

Fig. 3—Diagrammatic representation of main stages of the Glockner-Kaprun scheme

800 million kWh each year, from an installed capacity of about 330MW. Of this quantity of energy, about 200 million kWh will be consumed by the scheme's own pumping plant, operated for peak-load generation, leaving a net output of 615 million kWh, of which 469 million kWh is available during the winter half-year. The accompanying map, Fig. 2, the profile, Fig. 3, and Tables II and III give the general layout and essential data for the scheme. A glance at Fig. 2 shows that it is a two-stage development, with two principal reservoirs, each with its associated power station. There is also a subsidiary collecting area in the Möll catchment with its own reservoir (Margaritze reservoir) serving the upper reservoir of the main scheme through a pumping station.

All the main works are now completed or well advanced. Kaprun power station was the first part of the scheme to be built and was brought into operation during the war. Work was hurriedly started on the scheme after the occupation of Austria, to provide power for German industry. The tunnel from Wasserfallboden to Kaprun, together with the first two penstocks, were completed in 1944, and two 45MW Pelton wheel turbo-alternators were then brought into use. However, there was practically no storage available at the time, a temporary timber intake culvert leading to the tunnel from a small earth dam built just above the present site of Limberg dam. At that time there was sufficient flow (7 cumecs) to operate only one set at a time, but about 130 million kWh per annum (23,000,000 in the winter) was generated.

Further construction was intended during the war, but little was in fact achieved, except some preliminary works such as the construction of cement ropeways. After the war, the whole scheme was considered again, and evidently the upper works have been redesigned, since they incorporate some quite recent ideas in hydro-electric construction. Conditions immediately after the war were so unsettled, however (and were complicated by a failure of the existing intake dam), that it was not possible to start placing concrete in Limberg dam until 1948. On substantial completion of Limberg dam and two further lines of penstocks in 1951, two more sets, each of 55MW, were installed at Kaprun, to bring the station to its ultimate installed capacity of 200MW. Shortly before the completion of Limberg dam, work on the upper stage of the scheme was put in hand, and the two dams of the upper reservoir and installation of plant at Limberg power station are now almost finished.

Access roads to the main constructional sites were in themselves works of some magnitude ; they are shown in Fig. 2. The route to Limberg dam includes a funicular railway with cable haulage and a gauge of 8·1m, up an incline giving 431m rise in level over a length of 840m (maximum gradient 86 per cent). A large carriage, capable of carrying 60 tonnes, is hauled up and down this track and carries all supplies, &c., to the sites further up, except for those carried by the ropeways. Several other funicular railways, ropeways, and so on, were constructed to serve various sites, such as the tunnel adits. The cement ropeway stretches from the Kaprun railhead to the upper reservoir ; the various ropeways are not shown in Fig. 2. The subsidiary intake from the Kaprun River to the lower power station, shown in that illustration, is for

TABLE III—*Reservoirs and Hydrological Data for the Glockner-Kaprun Scheme*

	Top water level, metres above sea level	Useful storage capacity, cubic metres × 10⁶	Catchment area serving reservoir, square kilometres			Annual flow into reservoir, cubic metres × 10⁶		
			Direct	Indirect	Total	Summer	Winter	Total
Margaritze	2080	4	44·4 Möll	19·6 Leiter	—	99·6	12·8	112·4
	—	—	—	9·6 Käfer	—	13·3	2·7	16·0
	—	—	—	—	73·6	112·9	15·5	128·4
Mooserboden	2035	84*	21·8 Kaprun river	73·6 Margaritze	95·4	152·9	20·5	173·4
Wasserfallboden	1672	84·5	19·8 Kaprun river	95·4 Mooser-boden	115·2	185·2	26·8	222·0
Side stream intakes serving main stage tunnel :								
Grub	—	—	4·5	—	4·5	6·3	1·0	7·3
Zeferet	—	—	4·4	—	4·4	8·3	1·1	9·4
Total catchment serving Kaprun power station	—	—	—	—	124·1	199·8	28·9	238·7
Catchment for auxiliary sets at Kaprun power station	847	0·2	27·9	—	27·9	—	—	27

* Equivalent to about 68,000 acre-feet.

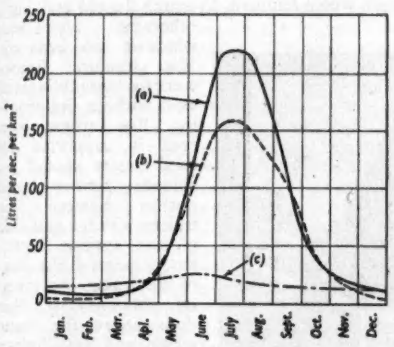
NOTE.—Mean rainfall varies between 2590mm and 1360mm per annum throughout the catchment.
Net winter power output is due to winter flow plus storage capacity = 28·9 + 168·5.

Power production per square kilometre of catchment : Upper stage ... 1·6kWh per square metre.
Main stage ... 4·1kWh per square metre.

two 0·27MW sets which generate power for local consumption. Winter access to Limberg is through a tunnel; from Limberg to Mooserboden it will be partly by tunnel and then by a ropeway car. The terminal stations of the ropeway are now under construction.

Hydrology of the Scheme

The Alpine flow regime, giving heavy flows in late spring and summer, is very marked in the catchments utilised by the scheme. The regime at Limberg is shown in the diagram, Fig. 4; higher up the curve is steeper still, as would be inferred from the large glaciers at the heads of the various streams. The areas taken up by glaciers vary from none in the small Grub catchment to 54 per cent of the Kaprun catchment above Mooserboden and 60 per cent on the Möll and Käfer streams. Other hydrological data is given in Table III. A storage of about two-thirds of the annual run-off is provided altogether, to give the proportions of summer and winter power quoted above. An appreciation of the importance of the two reservoirs is clearly given by Table III, which shows the quantities of water flowing into each reservoir during the summer and winter periods in an average year. The two reservoir sites offered natural advantages for this kind of development and, considering the size of the scheme, relatively short tunnels were needed (details are listed below Fig. 3) to give high heads at the two power stations. The pumping sets in the Limberg station do not affect the seasonal storage of the scheme, but are intended to help in meeting daily and weekly peaks in the Austrian grid by



	Sq km
(*a*) Kaprun River at Limberg, catchment area	41·5
(*b*) Möll River at Heiligenblut, catchment area... ...	74·5
(*c*) Danube River at Nussdorf (Vienna), catchment area...	101,707

Fig. 4—Flow curves for three Austrian rivers

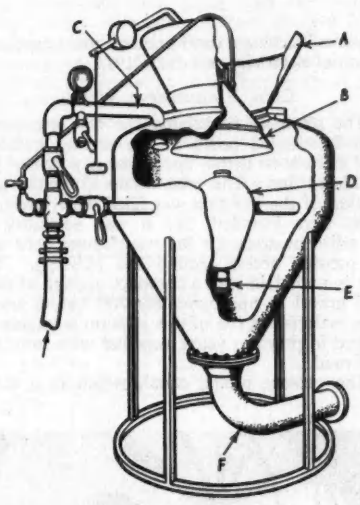
pumping at off-peak periods. Hence the power consumption and output due to pumping at Limberg are not listed in the body of Table II but shown at the end, for the extent to which the pumps are used does not affect the seasonal storage. Conversely, pumping from the Margaritze reservoir is essential for filling the Mooserboden reservoir. The topography of the site of Wasserfallboden indicates that a higher dam, and hence more storage, would apparently have been possible. So it can be inferred from the figures we have been discussing that, considering the Austrian grid system in that area, it has proved a better proposition to use the pumping plant for daily winter peaks than to provide more storage capacity for winter generation.

(*To be continued*)

Compressed Air Concrete Placer

Transport of mixed concrete over a horizontal distance up to 340m or a vertical distance of 60m is possible with the help of a compressed air plant built by Friedrich Wilh. Schwing G.m.b.H., Wanne-Eickel, German Federal Republic. The concrete is carried in pipes, and distances greater than those quoted are stated to be feasible. After the mix has been prepared, it is placed inside the compressed air vessel, which has a useful capacity of 500, 750 or 1000 litres (see accompanying illustration). For introducing the concrete the vessel has a bell-bottom hopper *A* at the top, the bell *B* having a special ring of nozzles for automatic self-cleaning. After the machine has been filled with concrete and the bell closed, compressed air is admitted, from six pipes *C* attached to a ring main, to the space above the level of the concrete. A cone *D* placed centrally inside the container has a compressed air pipe fitted with a nozzle head *E* and a non-return valve. The air admitted through this pipe helps to push the concrete into the concrete line *F*, which is situated below the cone *D*. At the same time, a certain amount of aeration takes place, which is of particular assistance in cases where the concrete is to be transported down a gradient.

The concrete is blown in a nearly unbroken



Pneumatic concrete placer

plug which, for a 500-litre machine and an inner pipe diameter of 150mm, has a length of 28m. About 30 cubic metres per hour can be handled with this machine. The concrete plug is divided into two at the exit of the pipe and the two halves are run into a closed vessel at the outlet of which they are reunited. This allows the admixed air to escape through a lateral opening and permits the concrete to issue quietly from the pipe. Normally, an operating air pressure of 6 atmospheres gauge is employed; for special cases plants for up to 10 atmospheres are built.

The maker has equipped his concrete pipes with quick-acting couplings. A telescopic pipe has been developed recently which can be extended and clamped to give lengths from 2m to 3·5m. Another item of equipment which has been specially developed is a distributor pipe with double-arc turning arrangement, and an adjustable bench for the outlet vessel.

By means of a flexible hose with up to 2in internal diameter and up to 30m long, concrete with up to 25mm maximum size of aggregate and a maximum content of 10 per cent of 15mm to 25mm grain size, can also be distributed over large areas or filled into shutters.

For spraying, a special nozzle is available which can be fed with compressed air through a lateral pipe. The velocity with which the concrete is sprayed depends on the pressure of the auxiliary air. Spraying can also be used for rendering surfaces in thicknesses which can vary from a small value to 10cm. The equipment is being handled in the U.K. by George Cohen, Sons and Co., Ltd., Wood Lane, London, W.12.

Paper from Bark-Stained Timber

After many years of development work, the Swedish Cellulose Company has introduced a process for the full utilisation of timber with heavy bark stains, which gives a pulp which is suitable even for high-grade white paper. The problem first arose about ten years ago when, because of the shortage of forest workers and the absence of transportable barking machines, it was found necessary to float spruce timber in its unbarked state. When this is done, up to 15 per cent of a spruce log is of inferior quality owing to bark stains produced during transport. These stains are due to phenols which are found in the sap bark at certain temperatures, and eventually cause darkened spots in the final product. Chemical methods to eliminate these compounds have been tried, but were found to be too expensive, even in those cases where the entire log could be saved.

The present method, besides being comparatively cheap, is said to have the advantage of rendering about 10 per cent more high-class pulp from injured wood, and to produce a commodity which is easier to screen and dry than ordinary pulp. It involves a two-stage cooking of the shives, the first cooking taking place in a solution containing 3 per cent of sodium sulphite, which is extracted after two to three hours. A calcium bisulphate cooking acid is then pumped in, and the cooking continued for about four hours, the time depending on the quality of the finished product desired. The solution drawn off from the first cooking, which amounts to some 75 per cent of the original quantity added, can be used again without reprocessing. It is claimed that the moderate increases in production costs (due to more expensive chemicals, the additional plant required, higher steam consumption, and additional labour) are more than compensated by the larger quantity of pulp which is obtained.

Measurements in Concrete Structures

The measurements and testing section of the Verein Deutscher Ingenieure is arranging a symposium on "Stress Measurements in Concrete Structures," under the chairmanship of Prof. Dr.-Ing. H. Ebner. It is to be held on October 19, 1956, at the Battelle-Institut, Frankfurt/Main. The following lectures will be given: "Experiences With Strain Measurements in Prestressed Concrete Structures," by Prof. Dr.-Ing. B. Fritz (Karlsruhe); "Strain Measurements of Concrete and Their Evaluation," by Dr.-Ing. G. Weil (Stuttgart); "Experiences With Measuring Installations in Thick Concrete Components," by Dr.-Ing. R. Kuhn (Munich); "String Strain Gauges as Remote Reading Instruments," by Dr.-Ing. Chr. Rohrbach (Berlin); "Measurement Capsules for Determining the Friction at the Base of Foundations," by Dr.-Ing. H. H. Emschermann (Berlin); "Measurement of the Coefficient of Friction in the Case of Prestressed Concrete," by Dr.-Ing. G. Mittelmann (Frankfurt/Main), and "Development and Testing of Instruments for Embedding in Concrete," by Prof. Dr.-Ing. H. Ebner (Mülheim/Ruhr), and Oberingenieur Fangerow (Hamburg).

Quality Tests for Household Goods

A "Federal Institute for the Testing of Household Products and for Research into Quality" has been founded by the Association of German Housewives (Deutscher Hausfrauenbund), Nuremburg. The institute will have as its object the testing of consumer goods and foodstuffs. In connection with this scheme, the Bayerische Landesgewerbeanstalt is to certify products as to their technical merits.

A fee is charged to the manufacturer, who obtains the right to refer in his trade publicity to the successful test. The introduction of a mark of quality will for the present not be undertaken. The reason for this is the bad experience with such a mark of quality which the "Association of German Housewives' Organisations" had introduced over twenty-five years ago, but which soon came under allegations of corruption in its administration. It is still somewhat doubtful whether the proposed use, for purposes of commercial propaganda, of the Institute's findings will be considered legal, since German law forbids the use of scientific test certificates for advertising. The new Institute is in addition to two similar ones, one of which is run by the RKW (German Productivity Council), and the other, at Munich, by Land of Bavaria.

Burlington Power Station

BY OUR AMERICAN EDITOR

The addition of a 200MW turbo-generator to the Burlington generating station of the Public Service Electric and Gas Company at Burlington, New Jersey, which went into operation at the end of last year, constitutes a good example of the most advanced current American power station practice. It employs steam conditions of 2350 lb per square inch gauge pressure, 1100 deg. Fah. initial temperature, and 1050 deg. Fah. reheat temperature, and it has a net heat rate of 8700 B.Th.U. per kilowatt-hour. The station comprises a semi-outdoor, pressurised water-tube boiler and a 200MW tandem-compound, triple-flow reheat turbine operating at a speed of 3600 r.p.m. The main alternator is a hydrogen-cooled, two-pole machine, generating three-phase alternating current at 13·8kV and 60 c/s.

THE Public Service Electric and Gas Company serves one of the more important industrial regions of the United States. Its supply area extends diagonally across the State of New Jersey in a long, narrow band from the New York state line to a point 10 miles below Camden. In this strip, 112 miles in length by 7 miles to 21 miles in width and approximately 1500 square miles in area, reside 3,500,000 people, or 80 per cent of the population of New Jersey. With the recent completion of the new 200MW turbo-generator installation at the Burlington generating station, the total capacity of the Public Service electric system has been increased to 2104MW. The major portion of the power produced by the company is transmitted from its five generating stations over a 132kV transmission grid which consists of a ring main surrounding the heavy industrial area in the northern part of the state with an extension to the cities of Trenton and Camden in the south. From fourteen switching stations situated on the 132kV grid, transmission at 26kV delivers energy to 155 substations. The Public Service system is interconnected with neighbouring companies at voltages ranging from 26kV to 220kV, thus becoming a part of an interconnected electric supply system having an installed capacity of some 8500MW.

To take care of the necessary growth of the system in the immediate future, the company is building two new generating stations, Linden and Bergen. The Linden generating station is now under construction at Linden, New Jersey, on land adjacent to the Bayway Refinery of the Esso Standard Oil Company. The first installation will consist of two units of 225MW each, which are scheduled for service in 1957. An interesting aspect of this new station will be the supply of large quantities of process steam to the Esso Standard Oil Company. The refinery will obtain its electric power from the Linden generating station and will supply the station with fuel and water. Preliminary plans for the construction of the Bergen generating station, in the company's rapidly growing northern area, began late in 1955. The station site is in Ridgefield, New Jersey, adjacent to the New Jersey Turnpike. The Bergen generating station will have two generating units of 275MW capacity each and is scheduled for service in 1958. On completion of the Linden and Bergen installations, the total effective generating capacity of the company's seven stations will approximate 3000MW.

The Burlington generating station is situated in the city of Burlington, on the Delaware River. The new 200MW unit at Burlington, which is illustrated in Fig. 1, is an extension of the existing power station, which has a forty-year history. Between 1915 and 1922, one 10MW and two 11MW units were installed. In 1932, a higher pressure and temperature boiler and turbine were installed. The exhaust steam from the turbine was fed into the three original turbines and the old boilers were removed from service. In the early 1940s, two 120MW cross-compound machines were installed. Finally, in 1955, the largest unit in the company's system, a 200MW tandem-compound unit, was put in service. The capacity of the latest unit at Burlington is twenty times the capacity of the first unit installed forty years earlier. The steam pressure has increased elevenfold, and steam temperatures have doubled. It now requires less than a third as much coal to produce a unit of electricity as it did in 1915.

Civil Engineering Work

The structure containing the new generating unit is situated north of the present building and extends to within approximately 70ft of the bulkhead line. The area occupied by the new section of the building was filled when previous units were installed, but it was necessary to fill adjacent areas for the transformer yard and to provide access around the building. The site is underlaid with a compact stratum of sand and gravel to approximately 20ft below grade. The material on top of this stratum is largely fill placed in previous years, together with some silt and mud.

The present intake canal, which is a steel-sheeted structure, was extended to the bulkhead line. The existing dock, situated at the bulkhead line, was continued eastward as far as the intake canal. This dock is of a relieving platform design and has a concrete face wall extending from platform level to finished grade.

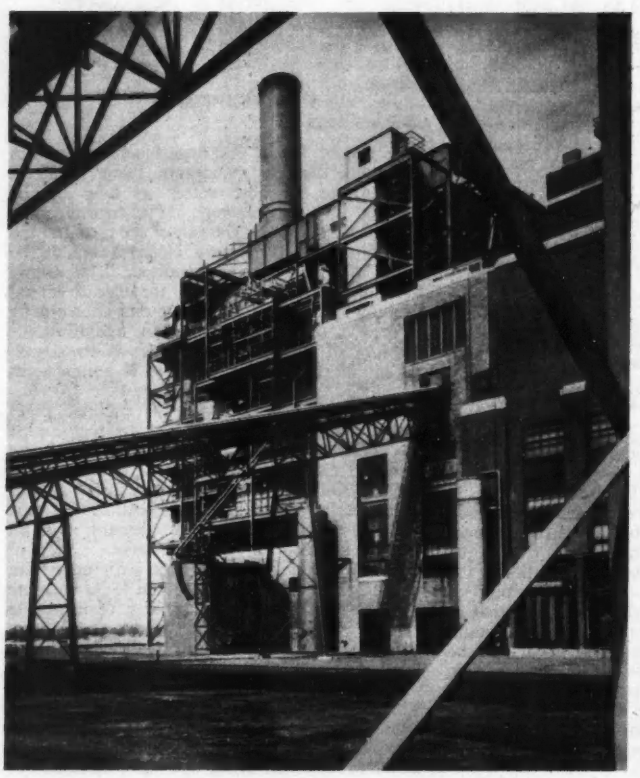


Fig. 1—Addition to the Burlington power station on the Delaware River in New Jersey

The structural addition, consisting of the boiler-house, turbine room, pulveriser bay and electric equipment bay, is an extension, north from the old station, measuring approximately 139ft in length by approximately 197ft wide. The turbine room is the same width as the present turbine room, 85ft, permitting the use of the existing crane for the new section. The pulveriser bay adjoining the present station is 25ft wide by approximately 92ft long. It is situated between the present boiler-house and the new boiler and contains the pulverisers, coal silos and coal conveyors above the silos. The boiler, unlike those in the existing station, is of the semi-outdoor design which not only reduces the duty of the ventilating system, but also results in a considerable saving in building cost, due to a reduction in the areas of exterior walls, floors and roof.

The foundations of the main building are carried to the sand and gravel 22ft below the turbine room floor. An allowable load of 6000 lb per square foot was assumed for these foundations. To distribute the column loads, a series of concrete beams, extending 10ft from the basement floor to the bottom of the foundations and varying in width from 6ft to 13ft, were provided. The foundations for the precipitator and for the structures in the transformer yard were supported on precast concrete piles. These piles were approximately 25ft long and carried a maximum load of 40 tons.

The new structure was designed to carry on as far as possible the architectural treatment of the old station, which accentuates vertical lines with high windows and pilasters at each column. Since the boiler is a semi-outdoor unit, the present temporary ends of the old boiler and bunker houses were changed to permanent construction. The building is faced with dark red brick trimmed with limestone. The face brick is backed with hollow tile of varying thicknesses. The window frames are steel, where required, to match the old building; otherwise aluminium windows are installed. The structural framework for the building is of steel without fire-proofing. The turbine room roof is supported by roof trusses spaced on column centres with purlins between the trusses. On the east side of the turbine room, the moments at the ends of the trusses are taken by columns 1ft 9½in deep above the crane girder, and 3ft 0½in deep below the crane girder. No moment is taken by the columns on the west side of the turbine room.

The floor construction consists, in general, of reinforced concrete slabs on steel beams. All of the platforms around the boilers and most of the interior platforms are of steel grating, with welded pipe handrail.

The roofs of the turbine room and miscellaneous structures above the main roof are precast concrete rib units 2ft wide. The interior finish of the various areas was selected to require a minimum of maintenance, as were those in the old building. The turbine room and electric bay are faced with 5in by 12in ceramic-glazed brick. The turbine room is separated from the boiler-house by a masonry wall finished with ceramic-glazed brick on the boiler-house side and ceramic-glazed tile on the turbine room side. The control room walls are made of insulated metal panels with double-glass windows for soundproofing. These windows are glazed with non-reflective glass. The ceiling is of enamelled steel, egg-crate panel construction, creating a luminous effect.

The screen well for the condenser circulating water is situated on the intake canal approxi-

mately in line with the condenser. It is of reinforced concrete construction with two pump compartments. As there is no house over the well, the screens, pumps and motors are outdoor units. Circulating water is carried from the pumps to the condensers through two 54in diameter reinforced concrete pipes, with the bottom of the pipes just above the turbine room basement. The discharge water within the building is carried in heavy concrete box culverts underneath the basement floor. Outside of the building the discharge water is carried in two 68in precast flat-base concrete pipes leading to the present steel-sheeted discharge canal. A 46in recirculating water line extending to the intake canal is available, if necessary, to prevent freezing in the intake canal.

The boiler is served by one steel chimney, 16ft 2in inside diameter and 102ft 11in high, which is supported on the structural steel frame in the air heater bay, 122ft above grade. It is lined with 3in of "Gunite," reinforced with 3in by 3in 10-gauge welded steel wire fabric.

Steam and Feed Water Flow

The new 200MW unit principally comprises a turbo-generator and boiler arranged on the unit system. The control room for this unit is situated at turbine floor level adjacent to the turbine and the boiler. The new unit is operated with practically no ties, electrically or mechanically, with the old station. Space limitations dictated that the boiler be placed alongside the turbine. The coal pulverisers are placed in front of the boiler, thus providing the shortest piping runs to the burners on the front of the boiler. The feeders of all pulverisers are accessible from one platform. All parts of the boiler are out-of-doors except the burner area and the bottom of the furnace. The drum of the boiler is enclosed in the boiler casing with a housing at each end.

As shown in Fig. 2, the feed water heating cycle includes eight stages of heating with six heaters and four drain coolers on the suction side of the boiler feed pumps. The first four stages of heating are carried out in two sectionalised two-in-one horizontal heaters situated in the condenser neck. All of the other heaters are of the vertical head-down design. One drain cooler is horizontal and the other three drain coolers are vertical head-down units. The heater shells are welded to eliminate flanges. Three boiler feed pumps and three condensate pumps are installed for the unit. In Fig. 3 we show the three "Worthington" boiler feed pumps, which are of the three-barrel, nine-stage horizontal design and are each driven at 3465 r.p.m. by a 3000 h.p. motor through an "American Blower" hydraulic coupling. The condensate and boiler feed pumps are paired electrically to operate through the same breaker from the same starting switch so that a condensate pump and its associated boiler feed pump start and stop together. This arrangement prevents damage to the boiler feed pump from low suction pressure. With boiler feed pump suction temperatures in the range of 400 deg. Fah. any drop in suction pressure below 250 lb per square inch gauge may result in damage to the pump in a matter of seconds. With the electrical arrangement provided the loss of a condensate pump automatically takes its paired boiler feed pump out of service. Make-up water for the boiler unit is obtained by demineralising the city water in a completely automatic mixed-bed unit having a capacity of 50 gallons per minute.

Boiler Plant

The interesting aspects of the new Babcock and Wilcox reheat boiler at Burlington include pressurised firing, flue gas recirculation and tempering, and relatively high steam temperatures and pressures. The continuous capacity of the boiler is 1,225,000 lb per hour, and the unit has a four-hour maximum rating of 1,350,000 lb per hour. The main steam temperature is 1100 deg. Fah. and the reheat temperature is 1050 deg. Fah. The superheater outlet pressure is 2389lb per square inch gauge. The furnace is of the wet-bottom design with continuous slag discharge. It is equipped to burn either coal or oil. As shown in Fig. 5, the furnace is about 48ft wide and 23ft deep and is divided by a water wall which has large openings to equalise the furnace pressure.

The high-temperature stage of the superheater, which is situated at the exit of the furnace, has pendant tubes arranged in platens widely spaced to take advantage of radiant heat and to reduce fouling. The reheater and low-temperature stage of the superheater are arranged in parallel in the gas passage with the low-temperature superheater on either side of the reheater. Both the reheater and superheater have a bank of pendant convection tubes, as well as four sections of horizontal tubes. The gas flow over these banks is regulated by dampers. Next in the gas path is the economiser, and finally there are two Ljüngstrom air heaters. At this point the flow splits as it enters the two decks of the flue dust collectors, which are of the combined mechanical-electrostatic design. The boiler normally operates as a pressurised unit, using only the forced draught fans. However, induced draught fans have been provided to permit suction operation in emergencies. There are twenty coal and twenty oil burners situated at four levels at the front of the boiler.

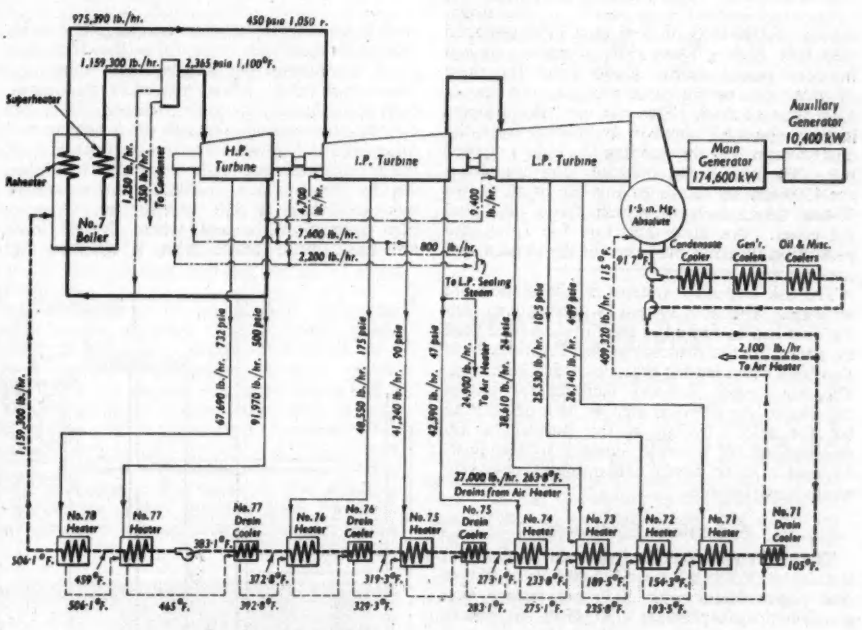
One gas recirculation fan takes part of the relatively cool flue gas entering the economiser and delivers it to two levels of furnace ports situated above the burners. The upper level provides tempering gas at full load to cool the gas entering the high-temperature superheater in order to minimise slagging. The lower level provides additional gas flow to help maintain steam temperature at low loads. Spray desuperheating is also provided in both the superheater and reheater to obtain additional steam-temperature control.

The furnace wall tubes are mainly 1 1/16 in outside diameter. The gas-leak tightness of the pressurised furnace is attained by a pressure casing which is tangentially mounted on the outside surface of the wall tubes. The boiler is provided with eighteen wall, twenty-eight retractable, and eight rotary soot blowers. They are air blowing units with electric motor drive and an electrical control which operates the blowers in a sequential system in accordance with a preselected pattern set up by the operator in the control room.

Steam Turbine and Ancillary Plant

The Westinghouse 200MW turbo-generator, which is illustrated in Fig. 6, operates at elevated steam conditions of 2350 lb per square inch gauge, 1100 deg. Fah. throttle, and 1050 deg. Fah. reheat temperature. It is a tandem-compound, 3600 r.p.m. machine consisting of a high-pressure section, a reheat single-flow, intermediate pressure section, and a triple-flow, low-pressure section. At these elevated temperatures, it is desirable to keep the amount of critical high-temperature materials to a minimum. This was accomplished in the case of the Burlington turbine by decreasing the heating of certain areas exposed to the hot inlet steam by using partially expanded steam as a coolant which is circulated over the exterior surfaces of the hot steam parts inside the outer casing before being exhausted to the reheater. The turbine drives the main and auxiliary generators in tandem. The auxiliary generator supplies power for the normal operation of the unit auxiliaries. An automatic fine fog spray fire protection system is provided for the lubricating oil reservoir, the storage tanks, the purification unit and the hydrogen detraining system.

The Worthington divided water box condenser has a surface of 80,000 square feet. It is of single-pass design with the tubes mounted parallel to the turbine axis. A single hot well is provided and de-aeration of the make-up and drains is accomplished with de-aerating trays in the main condenser. Fresh water from the Delaware River at the rate of 121,400 gallons per minute is used in the condenser. The entire main steam



Total output 185,000kW. Heat rate 8700 B.Th.U. per kWh (net).

Fig. 2—Steam and feed water flow diagram

system, from the superheater outlet header to the first-stage nozzle of the turbine, is made of austenitic columbium-stabilised 18–8 stainless steel. This includes the main steam piping, turbine throttle valves, control valve chests, inlet steam pipes, and a section of the inner high-pressure turbine shell. The main steam piping is made from seamless tubing. The materials of the superheater tubes, starting from the low-temperature end, are carbon steel, carbon-molybdenum steel, chromium-silicon-molybdenum steel, and titanium-stabilised 18–8 stainless steel. The hot reheat piping is made of 2¼ per cent chromium–1 per cent molybdenum seamless steel. The materials of the reheater tubes of the steam generator, starting from the low-temperature end, are carbon-molybdenum steel, chromium-silicon-molybdenum steel, and titanium-stabilised 18–8 stainless steel. The tubes carrying the reheated steam outside of the furnace to the principal header are made of chromium-molybdenum steel.

Coal Handling Plant

A particularly interesting aspect of the new unit is the coal handling system which embodies an active outdoor bunker pile. A swing-boom conveyor makes it possible to place approxi-

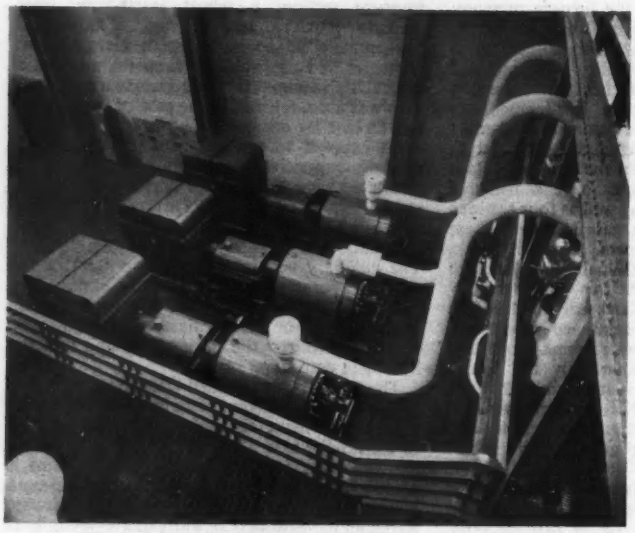


Fig. 3—Boiler feed pumps with hydraulic couplings and 3000 h.p. motors

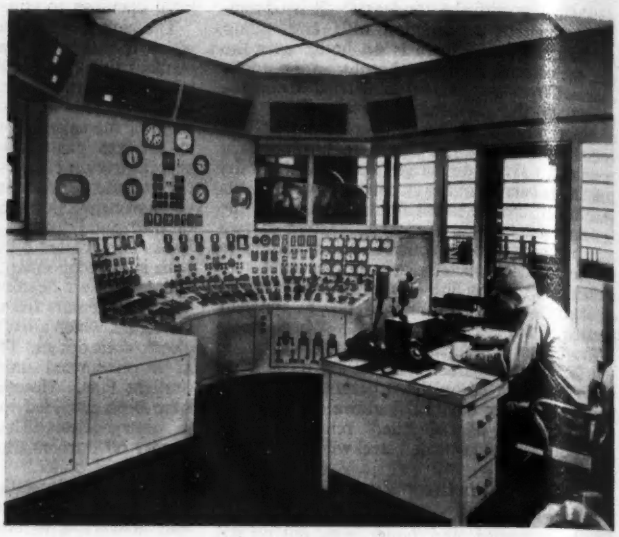


Fig. 4—Control room of the power station addition

mately 25,000 tons of coal in a kidney-shaped pile 60ft high. Three 12ft diameter conical hoppers placed below grade under the ridge of this pile permit reclaiming approximately 4500 tons of coal. The pile over the hoppers can also be maintained by bulldozing from the coal storage area surrounding the kidney-shaped pile. The coal is automatically conveyed from the 4500-ton active pile to any one or all of five 50-ton silos, each of which feeds one coal pulveriser. An automatic fine fog spray fire protection system is provided for the breaker and the adjacent conveyors.

The ash and dust systems of the station are separate. The dust system is arranged so that the dust can be refired in the furnaces or sluiced by jetting to the disposal area. Facilities have also been provided for the sale of dry bulk dust. The ash system includes facilities for jetting the slag to the disposal area or to a dewatering bin for sale. Pyrites at the pulverisers are disposed of by separate sluicing to the dust-disposal area to avoid contaminating the slag which is marketable.

Electrical Equipment

The main generator is hydrogen cooled and is rated at 205,882kVA or 175,000kW at 85 per cent power factor with 30 lb per square inch gauge hydrogen pressure. At 45 lb per square inch gauge hydrogen pressure the rating is 226,470kVA or 192,500kW at 85 per cent power factor. The speed of the machine is 3600 r.p.m. and the generator voltage is 13·8kV. The tandem-connected auxiliary generator is rated at 15,625kVA or 12,500kW at 80 per cent power factor.

The rotor of the main generator is inner-cooled by hydrogen flowing through the hollow field conductors to provide efficient heat transfer. The conventionally cooled stator has two windings with both ends of each winding brought outside the housing through 23kV, 6000A terminal bushings. "Transite" enclosures are used to protect the connecting buswork at the generator bushing terminals. The neutral of one winding is grounded through a neutral resistor. The neutral of the other winding is not connected to ground, thus avoiding circulating currents and eliminating buswork. The line ends of both windings are paralleled by connecting flexible copper braids to 9in by 9in by $\frac{1}{16}$in ventilated square copper tubular buses. From these busbars connections are made to the generator 15kV lightning arresters, potential transformers and the two main leads which carry the machine output to the two step-up transformers.

Each of the two main leads from the generator passes through a 23kV, 6000A gang-operated disconnecting switch before entering a cable system having eight 1,000,000 circular mil copper conductors per phase. Four pot-heads per phase are attached to 5in O.D. stainless steel pipes which extend to non-magnetic stainless steel manifolds that form the transition piece combining the single-phase leads into three-phase cables. Four 8$\frac{1}{8}$in O.D. steel pipes, each containing six cables, extend from the connection manifolds through the basement and tunnels to the power transformers outside. At the transformers the leads connect to overhead, 9in by 9in by $\frac{1}{16}$in ventilated square copper bus and then to the transformer. Copper bus connections, except where flexible leads are used, were made with a shielded arc welding process, using helium with carefully controlled current. All joints are butt-welded and reinforced with two copper splice plates welded to opposite sides of the bus.

One room, sound-proofed and air-conditioned, is provided for all the controls of the new unit. As shown in Fig. 4, the panel components are small in size and compactly arranged in a curved console. From his regular station, the operator sees only the instruments that are necessary to operate the plant. Instruments for record purposes only are situated in the wings

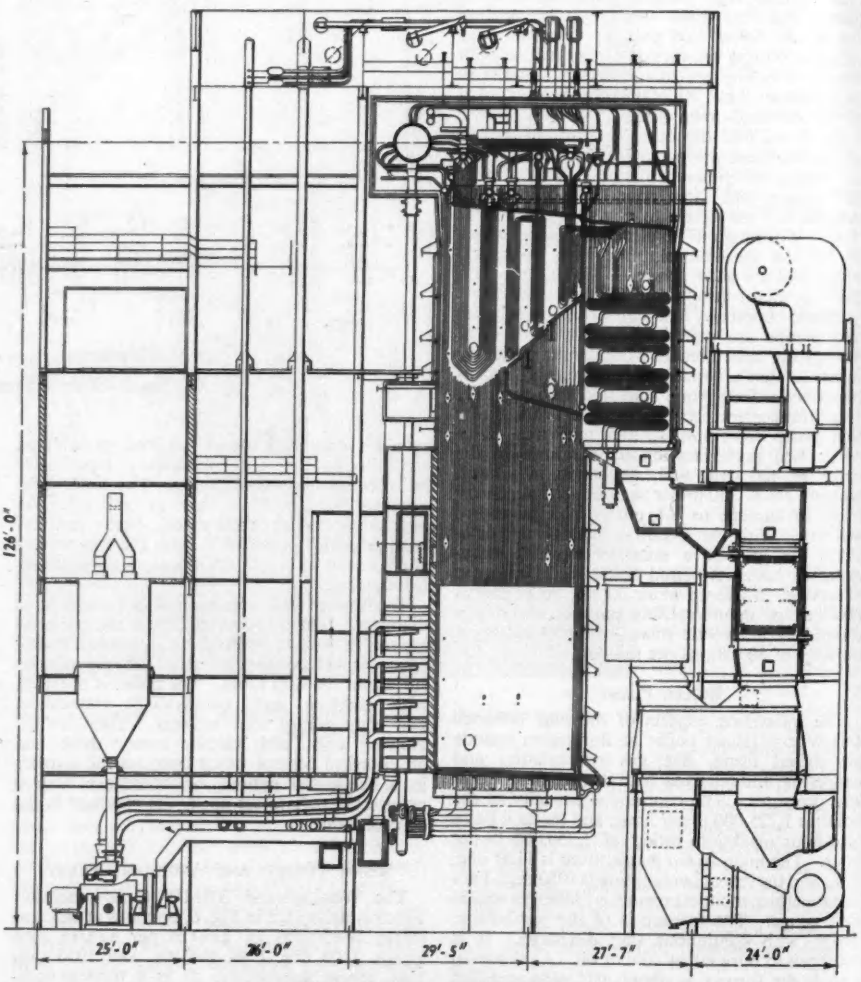


Fig. 5—Sectional elevation of boiler

of the control room. Telemetering is used extensively, and television apparatus is provided for viewing the combustion conditions in the boiler. A pair of boiler-drum water-level remote indicators of the compensated manometric design within view of the operator have eliminated the use of the traditional gauge glasses.

The step-up transformers consist of two three-phase units, rated at 130MVA. The emergency rating of one transformer permits it to carry approximately 75 per cent of the generator output if the other transformer is out of service. These transformers, weighing approximately 300,000 lb each, are rolled into position on bogies, each having two wheels. Two 21in reinforced steel beams are inserted beneath the transformer to permit the removal and storage of the wheels. The 132kV leads from the transformers to the switchyard are tubular cables; one lead is approximately 1300ft long, the other is approximately 2000ft long. Both the high and low-voltage leads are operated at an oil pressure of 200 lb per square inch gauge on a common oil pumping system. Each pipe is provided with a valve to isolate it from the oil system in case a leak develops.

Each phase of the 132kV leads consists of one 1,000,000 circular mil-segmental copper cable having paper insulation, shielding tape and half-round skid wire. The leads leave the transformer in three 3½in O.D. copper pipes which extend to a manhole. At the manhole the three copper pipes enter a bolted manifold. The three-phase leads leave this manifold in a single 8⅝in O.D. steel pipe. This pipe extends underground to the 132kV yard, except where it bridges the discharge canal on a structural member covered with a sunshade. The steel pipe is covered with a bituminous coating and is bedded in sand to provide better thermal conductivity and protection from mechanical damage. The only ground connection on the cable is in the manhole on the transformer end, with insulation provided at both the transformer entrance and the outdoor pot-heads. The single ground connection may be disconnected to determine whether there is any stray current flow and a small d.c. voltage may be inserted for cathodic protection, if necessary. In the 132kV yard the steel pipe from each transformer enters a welded manifold which is connected to a trifurcated manifold above ground. Three copper pipes, with offsets to compensate for expansion and contraction, carry the single-phase conductors from this point to pot-heads which connect to a section of the 132kV ring bus. Low voltage breakers are not used on the main generator, all switching being done with 132kV breakers in the ring bus.

The generator neutral resistor has a value of 560 ohms, allowing approximately 14A ground current to flow for a ground on the 13·2kV system. Duplicate high-speed over-current ground relays, connected to current transformers in the neutral ground resistor circuit, trip the generator in the event of a ground fault on the 13·2kV system. Each winding of the generator is protected against phase-to-phase faults by a three-phase high-speed differential relay connected to current transformers in the phase leads and their respective neutral leads. Protection for phase-to-phase faults up to and including the high-voltage oil circuit breakers is provided by a percentage differential relay for each phase.

The main generator receives its excitation from a four-field main exciter. The main exciter, in turn, receives its excitation from a shunt field, a small stabilising field, and either the "buck" or "boost" field which is energised by a magnetic amplifier regulator. When the regulator is not in service, the a.c. generator excitation is controlled by the motor-operated main exciter shunt-field rheostat. To provide maximum reliability of the regulating system, the a.c. supply is obtained from a permanent-magnet generator that is driven by an induction motor with sufficient inertia to carry the set through voltage disturbances. A nominal frequency of 420 c/s is used for the regulator power supply to obtain faster response, improved stabilisation and smaller components. Excitation for both the main and auxiliary generator is provided by a three-unit motor-generator set having a 375V, 850kW exciter for the main generator, a 250V, 75kW exciter for the auxiliary generator, and a 4160V, 1400 h.p. induction motor. The set is equipped with a flywheel to increase its inertia and the motor is designed to provide 500 per cent pull-out torque at rated voltage.

All auxiliary power apparatus is electrically driven and is supplied from a 4160V group busbar system. The 4160V, 15,625kVA, 0·8 power factor, direct-driven auxiliary power generator is the regular source of supply and a 9000kVA auxiliary power transformer is used for starting and as an emergency source. The generator is grounded through a 5 ohm resistor and is provided with differential and ground relay protection. The leads of the auxiliary generator are 3000A isolated-phase bus with four insulators at each support point. Below the generator this bus splits into three 2000A isolated phase busbars that feed three 4160V group busbars which are situated, respectively, at the 103ft, 114ft and 126ft elevations. To make it impossible to parallel the transformer and the auxiliary generator, the circuit breakers are interlocked by auxiliary switches so that one breaker cannot be closed unless the other is open. The auxiliary bus system is transferred between the two sources by the "dead throw-over" or interrupted source method. Relays automatically initiate the transfer from the auxiliary generator to the transformer source in the event of low bus voltage, a fault on the auxiliary generator, or a trip-out of the main generator due to a fault. This transfer is completed within forty cycles with an inrush current lower than the locked-rotor value. In addition to the automatic transfer from the generator to the transformer, manual transfer in both directions is provided. The busbars are de-energised for the same length of time during both automatic and manual transfers.

Wherever possible, the cables for control and miscellaneous supply are carried in cable trays rather than in conduit. Armoured cables are used for this purpose; the trays are made of expanded metal with angle-iron sides. Some aluminium-armour control cables are run in trays outdoors in the boiler area. In the building single-conductor "Neoprene"-jacketed mineral-base, rubber insulated power cables in iron conduits are used for the 440V service. "Neoprene"-jacketed oil-base ozone-resistant rubber insulated cables in iron conduits are used for the 4160V service. All control cables which must be run in iron conduits are rubber insulated, lead-jacketed. The control cables running to the transformer yard are carried in "Transite" conduits enclosed in a concrete envelope. In this system, all cable is rubber insulated, lead-jacketed.

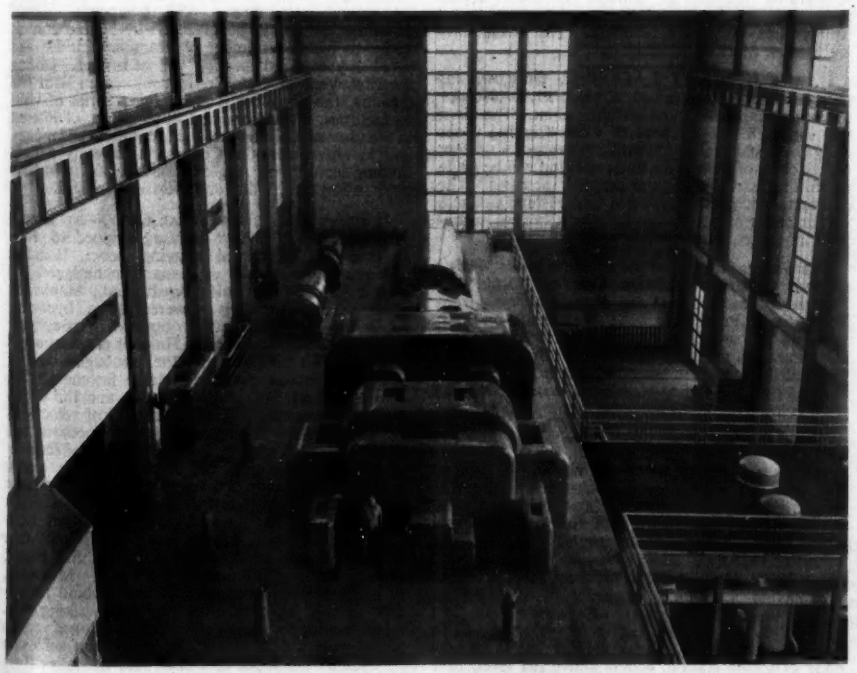


Fig. 6—Interior of the turbine room with 200 MW turbo-generator

Sustained Operation of Submarine Reactor Plant

THE successful conclusion of an interesting power demonstration by an atomic ship propulsion reactor was announced recently by the U.S. Atomic Energy Commission. The first American practical reactor power plant—the land-based prototype of the submarine "Nautilus" at the Commission's National Reactor Testing Station in Idaho—was shut down on August 8th, at the end of what is believed to have been the longest full-power run ever completed by any propulsion plant. On a single charge of uranium fuel, and using only part of that charge, the nuclear reactor operated at an average power of 100 per cent for more than sixty-six days and nights. The test was designed to prove the reliability and stamina of pressurised water reactors for ship propulsion. The prototype of the reactor now in the "Nautilus" met the most demanding requirements that could be placed upon it. At the end of the 1600-hour test the reactor still had many hundreds of hours of full operation available, and it has now resumed operation at varying power levels to obtain engineering test data and to train the "atomic" sailors of the U.S. Navy. These trainees, officers and men, will man future atomic power ships of the fleet.

The test demonstrated the feasibility of nuclear-powered ships cruising at high speeds and without refuelling for periods of time hitherto unattainable. Among the important benefits of the test was the obtaining of essential and heretofore unavailable information on reactor performance during extended high-power runs. This data will be used in the design of improved nuclear propulsion plants both for naval vessels and civilian nuclear power plants. To indicate the significance and magnitude of the operation it was pointed out that if the "Nautilus" itself had made a cruise for this length of time she could have steamed at top speed, submerged, around the world and many thousands of miles more. While the U.S. Navy ran the nuclear plant engineers of the Westinghouse Electric Corporation, which developed and built the reactor, studied its performance and gathered data.

Personal and Business

Appointments

LORD REITH has joined the board of the British Oxygen Company, Ltd.

E. K. COLE, Ltd., states that Mr. A. J. Brunker, chief engineer, has been appointed an executive director of the company.

MR. W. MORGAN THOMPSON, sales director of Monsanto Chemicals, Ltd., has been appointed a director of Monsanto Plastics, Ltd.

MR. L. DRUCQUER, M.I.E.E., has been appointed a director of the British Thomson-Houston Company, Ltd., Rugby, with special responsibility for home sales.

F. PERKINS, Ltd., Peterborough, states that Mr. Robert McGeachy has been appointed permanent instructor at an instruction school to be opened shortly in Australia by Perkins Diesel (Overseas) Pty., Ltd.

MR. E. C. STEVENS has been appointed managing director of Skil Engineers, Ltd., Chell Street, Longsight, Manchester, 12, in succession to Mr. H. Livingstone, who has resigned from the board of the company.

MR. W. J. MCBRIAN has been appointed chairman and managing director of Caterpillar Tractor Company, Ltd., Desford, Leicester. He will continue to hold his office of vice-president of the Caterpillar Tractor Company of America.

VENNER, Ltd., New Malden, Surrey, states that Lieut.-Colonel Laurence Bingham, general sales manager, is now sales director ; Mr. E. Tauchert, M.I.Mech.E., general works manager, has become works director, and Mr. W. H. Marsden, secretary, has been appointed a director.

MR. E. W. RATCLIFFE, M.I.C.E., has been appointed divisional engineer (North Western), Liverpool, of British Transport Waterways. He is to succeed Mr. A. Muir White, M.I.C.E., who is retiring from the position on October 1st, but who will continue in an advisory capacity until next June.

THE A.E.I. LAMP AND LIGHTING COMPANY, Ltd., has announced the appointment of Mr. J. B. Henderson as regional publicity assistant for Scotland and Northern Ireland. Mr. Henderson is to take charge of the new lamp and lighting showroom which the company has opened at Waterloo Street, Glasgow.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, announces the appointment of Mr. F. L. Field as assistant, sales management, and of Mr. J. Cannell as assistant to sales manager, plant department. These appointments result from the fact that the contracts department has now ceased to be a separate department.

THE MINISTRY OF SUPPLY has announced the following appointments at the Royal Aircraft Establishment, Farnborough :—Mr. E. C. Cornford, head of guided weapons department ; Mr. D. J. Lyons, senior superintendent, ballistic missiles division of the guided weapons department ; Mr. P. A. Hufton, senior superintendent, supersonics division of the aerodynamics department.

TILTMAN LANGLEY, Ltd., has announced the resignation, owing to ill health, of Mr. Marcus Langley from the position of managing director. He will continue to serve on the board. Mr. A. Hessell Tiltman has been appointed president of the company, and Major H. H. Sykes has become acting managing director. Mr. L. A. Wingfield has been appointed chairman.

SHEEPBRIDGE ENGINEERING, Ltd., states that Mr. R. W. T. Bray has been appointed managing director of W. E. Bray and Co., Ltd., and that Mr. H. Gunner has joined the board. Mr. Gunner is the managing director of the southern group of companies of Sheepbridge Engineering, Ltd. Mr. D. J. Harrowell has been appointed technical director, and Mr. C. Edwards, works manager, of W. E. Bray and Co., Ltd. Mr. W. J. Collard has been appointed a director and the general manager of Harold Andrews Sheepbridge, Ltd., Halesowen, Birmingham, and Mr. J. H. Lomas has become managing director of that company.

Business Announcements

MR. FRED SENIOR, Bourton, Rugby, is now the sole agent in this country for " Kabeschlepp " cable drag chains.

THE INSTITUTE OF METALS has moved to 17, Belgrave Square, London, S.W.1 (telephone, Belgravia 3291).

THE SIMON ENGINEERING GROUP has moved its London branch offices to Simon House, 28–29, Dover Street, W.1 (telephone, Hyde Park 8191).

THE HYDRONYL SYNDICATE, Ltd., 14, Gloucester Road, London, S.W.7, states that its telephone number has been changed to Knightsbridge 6803.

HYGROTHERM ENGINEERING, Ltd., states that its London office has been moved to 5, Fitzhardinge Street, Portman Square, W.1 (telephone, Welbeck 6813).

Contracts

BIRLEC, Ltd., Erdington, Birmingham, 24, has received an order to build three roller hearth furnaces at the new Tannochside factory of Caterpillar Tractor Company, Ltd.

HENRY MEADOWS, Ltd., Wolverhampton, states that Automobile Products of India, Ltd., Bombay, has placed a repeat order to the value of £1,000,000 for diesel engines and gearboxes.

FERODO, Ltd., Chapel-en-le-Frith, Stockport, has received a contract worth more than £A250,000 for the supply of non-metallic brake blocks to the New South Wales Government Railways for their electrified suburban lines.

ASHMORE, BENSON, PEASE AND CO., Stockton-on-Tees, has received the contract for the construction of the blast-furnace and the ore unloader and stocking bridges, which comprise part of the latest extensions put in hand by the Steel Company of Wales, Ltd.

COSTAIN-JOHN BROWN, Ltd., and WILLIAM BROTHERS (of Oklahoma) have received from the Turkish Government a NATO contract valued at £5,500,000 for the construction of oil line pumping stations, marine terminals, tank farm facilities and interconnecting pipe lines. The first teams of technecians will travel to Turkey early in October, and work will begin at the end of this year.

THE GENERAL ELECTRIC COMPANY, Ltd., has received from the Central Electricity Authority a contract valued at £689,000 for an outdoor switching station to be erected near Wolverhampton. The new substation will include a seventeen-switch section for service at 132kV and a three-switch section operating at 275kV. The contract covers the circuit breakers, together with the associated air-break isolators and busbars, for both sections of the new substation.

THE BRITISH THOMSON-HOUSTON EXPORT COMPANY, Ltd., has been awarded a contract, valued at over £2,000,000, for the whole of the 330kV switchgear for the Kariba hydro-electric scheme of the Federal Hydro-Electric Board, Federation of Rhodesia and Nyasaland. The order covers six complete 330kV substations located at Kariba, Kitwe, Norton, Sherwood, Salisbury and Bulawayo, incorporating twenty-three oil circuit breakers. The consultants are Messrs. Merz and McLellan.

G. AND J. WEIR, Ltd., Cathcart, Glasgow, has received a contract, valued at over £1,000,000 for sea water evaporating and distilling plant. The plant will supply 896,000 gallons of fresh drinking water daily to the Netherlands Antilles island of Curacao, off the coast of Venezuela, and provision will be made for future extensions as the demand increases. The contract, which has been placed by the Island Council, also includes power station buildings, boilers, turbo-generating sets, pumps and piping.

THE FRASER AND CHALMERS ENGINEERING WORKS OF THE GENERAL ELECTRIC COMPANY, Ltd., has recieved contracts to the value of some £200,000 from Forges de la Providence S.A., Marchienne-au-Pont, Belgium, for ore blending, crushing, screening and sampling equipment. Low-grade ore from the Briey district and imported Swedish ore will be handled by the blending equipment, densities varying from as low as 1·6 tons per cubic metre up to 3·2 tons per cubic metre. The consultants are John Miles and Partners.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received, through Australian Electrical Industries Pty. Ltd., an order for switchgear, for voltages over 300kV, for the Snowy Mountains hydro-electric scheme in Australia. The order is valued at £125,000. The new switchgear will consist of five 330kV air-blast circuit breakers, rated at 1200A and having a breaking capacity of 10,000MVA, together with the necessary compressor plant, and eighteen 330kV outdoor current transformers (with multiple secondaries). It will be installed in an outdoor switching station, 4500ft above sea level, near the T1 underground power station of the Snowy Mountains Hydro-Electric Authority.

Miscellanea

CANADIAN BUILDING RESEARCH NOTES.—We have received from the Canadian Division of Building Research, of Ottawa, the first seven of a series of " project notes " which it is intended to publish on the first of each month. Each note deals with one of the Division's research projects and comments on its scope and usefulness. The objects so far described are as follows : concrete slabs for basementless houses; efflorescence; the Canadian snow survey; chimney studies ; conductive flooring ; fire fatalities ; and winter construction.

MACHINE SHOP FOR APPRENTICE TRAINING.—The training facilities at the Witton Engineering Works of The General Electric Company, Ltd., have recently been augmented by the establishment of a new machine shop devoted exclusively to the instruction of apprentices. The building, which occupies an area of 5500 square feet, is equipped with a selection of modern machine tools and the new school will be used to provide all apprentices with training in the fundamentals of general machine shop practice before they enter the production departments of the works.

WATER SPEED RECORD ATTEMPT.—The present holder of the world's speed record on water, Mr. Donald M. Campbell, has taken his turbo-jet speedboat, " Bluebird," to Lake Coniston to attempt to raise his record. The boat has been modified, principally to reduce the risk of water entering the engine air intakes and since the English lake offers a run of only 4 miles instead of the 6 miles at Lake Mead, a braking drogue is being developed. A colour film of the successful record attempt at Lake Mead has been made by the Socony Mobil Oil Company, and shows graphically the magnitude of the spray problem on craft of very high performance. Mr. Campbell has observed that the U.S. lake had the great advantage of being only about 30ft deep, facilitating escape of the pilot and salvage of the craft in case of disaster, but that recent drought had greatly reduced the surface of the lake this year. The attempt will be made as soon after September 15th as the craft is ready and the weather is favourable.

BRITISH-SWEDISH CHAMBER OF COMMERCE.—It is announced that the British-Swedish Chamber of Commerce in Sweden has postponed its annual general meeting, which is normally held in Stockholm during September. In its place a special meeting will be held aboard the Swedish Lloyd vessel s/s " Suecia " on October 3rd at Millwall Docks in London. This is probably the first time that a Chamber of Commerce established outside the United Kingdom has brought its own members by ship to the British Isles. It is hoped that this arrangement will give many British firms the opportunity of establishing personal contact with their Swedish counterparts and of holding business discussions wtih them. The postponed annual general meeting will be preceded by a luncheon on board to which a number of prominent British and Swedish guests and speakers will be invited. During the first week of October, in conjunction with this meeting, the Chamber is arranging a series of visits to factories, institutions and other places of interest in the Greater London area. Later during the month, and in November, the Chamber's secretary will be holding lectures on Anglo-Swedish trade in various cities in England, Wales and Northern Ireland.

AIRCRAFT FOR AGRICULTURAL DUTY.—An aircraft designated the " E.P.9 " is being shipped to New Zealand for agricultural spraying work. It is the first production model of a machine designed and built by Edgar Percival Aircraft, Ltd., Stapleford, Essex. The aircraft is powered by a Lycoming " GO-480-B " horizontally opposed, six-cylinder engine of 270 h.p. driving a Hartzell constant-speed airscrew of 7ft 6in diameter ; the four engine-cowling panels are fitted with quick-release fasteners. The span is 43ft 6in and length 29ft 6in, and the undercarriage has been designed for a vertical velocity of 9ft per second. The cockpit accommodates two pilots, with dual control, and up to 1 ton of fertiliser or spray liquid can be carried. The design of the aircraft, incorporating as it does a cargo space of 185 cubic feet, permits many other uses in addition to agricultural spraying. The " E.P.9 " has aptly been described as a " flying jeep," for it could take five passengers, or could be used on fire patrol, rescue, or supply delivery duties. Moreover, as a flying ambulance, the " E.P.9 " could accommodate two stretcher cases and one walking case, together with an attendant. The agricultural version has a gross weight of 3980 lb, and it can achieve a continuous top speed of 140 m.p.h., the take-off (in a 5 m.p.h. wind) being 115 yards, and rate of climb 990ft per minute.

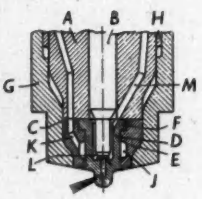
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

INTERNAL COMBUSTION ENGINES

755,316. November 3, 1954.—Fuel Injection Valves, Aktieselskabet Burmeister and Wain's Maskin-Og Skibsbyggeri, No. 4, Strandgadi, Copenhagen, Denmark. (*Inventor*: *Ove Petersen.*)

A fuel injection valve according to one embodiment of the invention is shown in the drawing in axial section and partly diagrammatically. *A* is the guide member of the valve, in which is the spindle *B* which has a plane lower end face *C*. The injection nozzle or atomiser proper is composed of an atomiser body *D* and a surrounding cooling body *E*. The atomiser body has at its top a collar *F* resting in a recess in the body. The upper faces of the atomiser body and the cooling body are kept in sealing contact with the lower face *C* of the valve guide by a union nut *G* on a screw thread *H*. Coolant is supplied to an annular space *J* through a supply channel *K* in the cooling body and the valve guide and leaves through an outlet channel, not shown, through the same parts. In the upper part of the atomiser body *E* is a wide bore *L*, which serves as a fuel chamber, which, through a channel *M*, is in communication with a fuel pump, and which receives the lower end of the valve spindle, this lower end being of smaller diameter than the remaining portion of the spindle. The bore *L* has a plane bottom forming the valve seat, from which the fuel channel of the atomiser body issues. The valve seat is countersunk below the upper surface of the atomiser body and the fuel channel has a very limited length, preferably of the order of magnitude of 7mm to 10mm. At the same time it is so narrow that the velocity of the fuel in the channel during the injection operation proper can be at substantially the same order of magnitude as the velocity in the atomiser holes (only one of which is shown in the drawing) at the lower end of the channel. These atomiser holes are provided in a nose portion of a smaller diameter than the main portion of the atomiser body *E*, so that the atomiser holes are of short length. —*August* 22, 1956.



No. 755,316

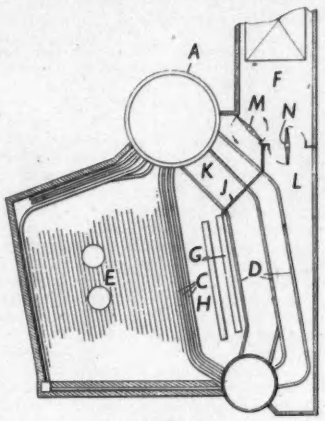
756,059. September 9, 1953.—Motor Vehicles, Stephen Silvester Lancefield, 87, South Norwood Hill, London, S.E.25.

The invention relates to improvements in motor vehicles. There is a popular class of racing cars using air-cooled engines, usually of 500 c.c. capacity and, in the main, these are single-cylinder, vertical engines, though multi-cylinder, vertical, air-cooled engines are also used. The invention is concerned with such cars and similar vertical engines are commonly used in racing motor-cycles. The drawing of the invention (not reproduced herewith) shows the engine has its crankshaft transverse to the length of the vehicle and is tilted backwards—that is, its cylinder axis is inclined backwards with respect to the vertical sufficiently to permit the carburettor body to lie horizontally with the throttle chamber vertical. The cylinder cooling fins display a considerable plane surface to the airstream which is, of course, horizontal when the vehicle is moving. The centre of gravity of the engine is lowered somewhat for a given position of crankshaft axis and there is rather more room for the exhaust pipe than with a vertical engine. It will be also appreciated that the backward tilting of the engine is advantageous even with a fuel injection system, for the sake of cooling and a dry crankcase.—*August* 29, 1956.

STEAM GENERATORS

755,542. January 18, 1954.—Vapour Generators, Foster Wheeler, Ltd., Foster Wheeler House, 3, Ixworth Place, London, S.W.3. (*Inventor*: *Leonard James Culver.*)

The boiler, as shown in the drawing, is a D type single-furnace water-tube marine boiler having a steam drum *A* connected to a water drum by two banks of boiler tubes *C* and *D* arranged between a furnace *E* and a flue *F*. The outer bank is more substantial than the inner bank. A superheater *G* is arranged close to the outer bank with a space *H* between it and the inner bank somewhat wider than its own width. The superheater goes right through the boiler. It terminates at the base near the lower water drum but at the top well short of the steam drum *A* so that furnace gases which have passed through the inner bank *C* can pass through the outer bank *D* to the flue *F* without passing through the superheater but through the space between its upper end and the steam drum. At the level of the top of the superheater a baffle *J* divides the outer bank into two sections. The baffle extends upwards away from the superheater normally to the tubes in the bank *D* so as to define with the steam drum a gas passage *K* of substantially constant cross-section along its length. Its slope is sufficient to prevent the deposition of soot. Beyond the outer bank the baffle *J* is extended into the flue *F* so as to provide two parallel gas passages *K* and *L*. A damper *M* and *N* is arranged across each of the passages. By adjustment of these dampers the relative gas flow through the two passages can be varied. If the gas passage *K* above the partition is closed the furnace gases can pass to the flue *F* only by passing through the superheater *G* and therefore the steam temperature will be a maximum. If that passage be progressively opened while



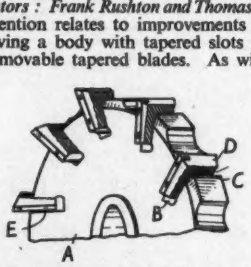
No. 755,542

the other passage is progressively closed a progressively large proportion of the gases will be caused to by-pass the superheater and the steam temperature will be lowered. Thus, for any particular rate of steaming the superheat temperature can be varied by adjustment of the dampers. By designing the gas passage *K* above the baffle *J* so that a substantial proportion of gases can be passed through it a wide range of steam temperatures can be obtained for any particular rate of steaming. A boiler designed to produce steam at 850 deg. Fah. over a wide range of loads can, by means of the invention, be made to produce steam when desired at a temperature as low as 600 deg. Fah. at any particular steaming rate. The invention also allows the boiler to be given an "inverted superheat characteristic" to allow the steam temperature to decrease with increase of load. It can be contrived, for example, that a steam temperature of 850 deg. Fah. can be obtained up to 50 per cent evaporation and a steam temperature of 750 deg. above 50 per cent evaporation without prejudicing the ability of the boiler to produce steam at 700 deg. Fah. at all normal rates of evaporation. The actual performance depends on the relative proportion of heating surface in the two parallel gas paths.—*August* 22, 1956.

WORKSHOP TOOLS AND APPLIANCES

755,847. August 11, 1953.—Milling Cutters, Brayshaw Furnaces and Tools, Ltd., Belle Vue Works, Boundary Street, Manchester, 12. (*Inventors*: *Frank Rushton and Thomas Maguire.*)

The invention relates to improvements in milling cutters having a body with tapered slots to accommodate removable tapered blades. As will be seen

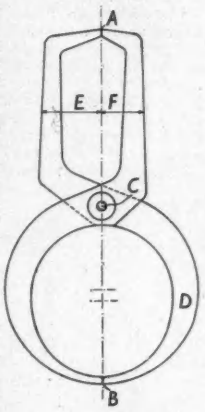


No. 755,847

from the drawing, the cutter body *A* has a series of slots *B* tapering from the periphery and formed with inclined serrations *C* on one face to receive correspondingly inclined serrations on blades *D*. In use adjustment in one direction is carried out by inserting a shim *E* and driving the blade into the slot, but as a result of the inclination of the serrations an adjustment at right angles will automatically also take place. The relationship between the two adjustments is controlled by the angle of inclination of the serrations. In a blade having a taper of 5 deg. between the plain and serrated faces and serrations on the blade and body inclined at an angle of 7 deg. to the bottom of the slot, the use of a 0·005in shim will give an adjustment to the blade of $\frac{1}{16}$in in one direction (outwardly) to compensate for grinding the blade and 0·007in in the direction (laterally) at right angles by raising the blade in the slot. Other results may be obtained by different angles of inclination of the serrations, thickness of shim, and differing taper. A modified arrangement for a cutter in which the blades are arranged to project alternately from opposite sides is also shown in the specification.—*August* 29, 1956.

755,989. February 26, 1954.—Improved Callipers, Stephen Silvester Lancefield, 87, South Norwood Hill, London, S.E.25.

The invention has for an object to provide a calliper device whereby parts which are inaccessible for measuring purposes by ordinary callipers can be accurately measured. Referring to the drawing, *AB* is a straight line passing between the two sets of measuring faces, when the device is closed, and through the pivot *C*. The distances *AC* and *CB* are equal. Thus, as the device is opened for measuring, the faces at each end move through equal arcs together and therefore the distance between each pair of faces is equal. If an object is felt by one pair of faces its thickness can be determined by applying a rule, slip gauge, or other suitable device to the other pair of faces. It will be noted that in this example on one side of the pivot the limbs *D* are curved, whilst at the other side of the pivot the limbs are straight. It will be seen that the distance *E* is greater than the distance *F* and it will be appreciated that the measuring face of the left-hand limb can sometimes reach a surface inaccessible to the right-hand limb and vice versa. The pivot is adjustable for tightness.—*August* 29, 1956.



No. 755,989

METALLURGY

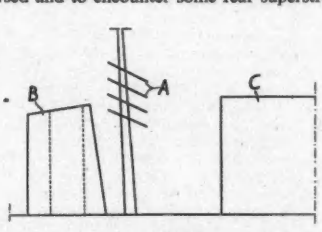
755,963. November 2, 1953.—Chilling Cast Billets in Continuous Casting Plants, Gebr. Böhler and Co., Aktiengesellschaft, Elisabethstrasse 12, Vienna, 1, Austria.

The invention is an improvement in or modification of the process for cooling continuously cast billets outside the mould in continuous casting plants as claimed in the specification No. 755,525/53. It is characterised by the feature that the cooling is effected by spraying the billet with a cooling medium from nozzles distributed along the entire cooling length of the billet, from the mould outlet to about the point of complete solidification of the core, the distance between the nozzles progressively increasing with increasing distance from the outlet of the chill mould.—*August* 29, 1956.

MARINE ENGINEERING

755,910. October 27, 1954.—Directing Device for Ships' Funnels, Societe des Forges et Chantiers de la Mediterranee, 25, Boulevard Malesherbes, Paris (8), France.

The invention relates to fluid-flow controlling devices for use on ships, where the superstructure situated forward of or in the vicinity of the funnel causes considerable disturbance of the air in the region of the funnel, thus causing the smoke to be dispersed and to encounter some rear superstructure



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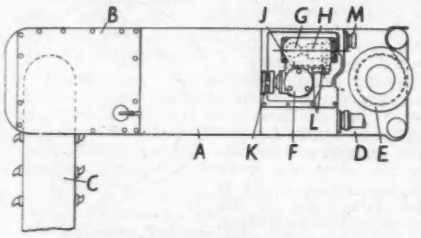
or to be forced down on to the decks. As will be seen from the drawing, the device is constituted by two or more thin inclined surfaces or planes *A* arranged forward of and at a suitable distance from the funnel *B*, rising from the front towards the rear so as to

form with the horizontal an angle determined as a function of the trajectory which it is desired to impart to the smoke or fumes in order to avoid their encountering all or part of the superstructure situated astern of the funnel. At *C* there is shown an obstacle such as a deckhouse, which disturbs the flow of air forward of the funnel, this superstructure causing at the same time a generally downward inclination of the air flow, which will be compensated by the slight upward inclination of the surfaces *A*. In order to avoid the necessity of providing supports specially for the device, the planes *A* can be supported by a mast situated forward of the funnel. A modified arrangement is also shown in the specification.—*August* 29, 1956.

MINING ENGINEERING

755,423. January 15, 1954.—COAL CUTTING MACHINES, Gebruder Eickhoff Maschinenfabrik u. Eisengiesserei m.b.H., Hunscheidtstrasse 176, Bochum, Germany. (*Inventors: Wilhelm Dewenter, Josef Kammann and Willi Lanfermann.*)

The aim of the invention is so to design a coal cutting machine that the number of loose pipes for the conveying of liquid is reduced or eliminated. As will be seen from the drawing, the coal cutting machine is divided into a housing *A* containing a motor, a cutting head *B* with a cutting chain-carrying jib *C*, and a winch housing *D*. In this housing is the hydraulic drive for a winch *E*, and it consists of a pump *F*, a hydraulically actuated motor *G* and a control valve *H*. These elements are contained in a



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common block *J* in the winch housing *D*. The drive of the pump *F* is through a clutch coupling *K* from the main motor. The shaft of the pump lies so that the block can be installed in and removed without separating the housings. The pipes which interconnect the pump, the valve, the motor are formed by channels *L* cast or drilled inside the block *J*. The axis of the shaft of the motor *G* is vertical and the axis of the control valve *H* horizontal. Adjustment of the control valve to alter the direction of rotation of the winch *E* can be done through an intermediate gearing by means of a handle *M* from the front of the machine.—*August* 22, 1956.

Technical Reports

The Calculation of Flux Losses and Forces in Iron-Cored Reactors with Distributed Air Gaps (Ref. Q/T137). By M. Waters, B.Sc., M.I.E.E. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 12s., postage 3d.—Methods are given for calculating the flux and losses of both tapped and untapped reactors. Reasonable accuracy may be expected from flux calculations, but fringeing and leakage fluxes are sufficiently large to make exact estimation of stray iron losses very difficult. It is suggested that empirical methods are the most practical way of dealing with such losses. Electromagnetic forces are moderate in untapped reactors, and although there is a considerable radial leakage flux in tapped reactors the ampere turns are usually small, since these are often shunt reactors which cannot be subjected to short-circuit currents. Formulæ for calculating the forces are given.

Diesel Locomotives in Mines: The Fire Hazard from Hot Surfaces on the Exhaust System. By V. O. Hardy, R. Hattersley and P. G. Taigel. Ministry of Fuel and Power Research Report, No. 126. H.M. Stationery Office. Price 2s. 3d.—The experiments on the cooling of the exhaust system on a diesel locomotive described in this report form part of an investigation of the fire hazard arising from the heating of deposits of coal dust and oil on hot surfaces. Measurements were made under conditions of test approaching full load, of temperature, and water consumption of the exhaust system, of a hitherto standard and a modified 70 h.p. mines-type diesel locomotive. The surface temperature of the exhaust system on the standard locomotive was found to vary from a maximum of 438 deg. Cent. on the manifold to 277 deg. Cent. on the conditioner top. Water consumption was 6½ gallons in a run of one hour with this locomotive. By using a water-cooled manifold and a larger fan, together with a water jet in the exhaust pipe, a new design of conditioner box and the air inlet filters outside the engine casing, the temperature throughout the exhaust system was greatly reduced. The maximum temperature, 274 deg. Cent., occurred on the vertical exhaust pipe whilst the lowest, 76 deg. Cent., was on the conditioner top. The improved cooling with the new system was achieved with an increase in water consumption from 6½ to 13 gallons per hour at "full load." The use of the new design of conditioner box together with the water spray in the exhaust pipe in combination with the air cooled manifold of the hitherto standard locomotive has also shown a marked reduction in the surface temperature of the conditioner box. Some experiments show that by placing the combustion air intake outside the engine compartment the amount of carbon monoxide in the exhaust is reduced from 0·198 per cent to 0·114 per cent with a reduction of some 30 deg. Cent. in the temperatures throughout the exhaust system of the hitherto standard locomotive.

Nouvelle Méthode Approchée de Calcul des Couches Limites Laminaire et Turbulente en Ecoulement Compressible. By A. Walz. Publications Scientifiques et Techniques du Ministère de l'Air, No. 309. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price 950 francs.—In general, the approximate calculation of the boundary layer in compressible flow has been founded upon the equation of motion. From this, a first order differential equation may be derived which may be solved for a single characteristic quantity of the boundary layer, e.g. the thickness. The velocity profile inside the layer can then be calculated approximately using the boundary conditions. The method is considerably inaccurate already in the case of incompressible fluids, and even more so in the case of compressible fluids. In the latter case, it is particularly important to take into account the energy balance in the boundary layer. The greater complexity of the resulting equations still remains acceptable if one makes certain simplifying assumptions, which, in many cases, do not introduce excessive errors. These are adiabatic conditions in the boundary layer, a value of the Prandtl number equal to unity, and a velocity profile expressed by a single parameter. Much time can be saved by using graphs and nomograms for those functions which recur more generally in the actual calculations.

The present monograph gives the results of the author's work, which was aimed at facilitating, by means of graphs, the systematic analysis of the boundary layer, whether laminar or turbulent, up to Mach 12.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF PUBLIC LIGHTING ENGINEERS

Tues. to Fri., Sept. 18th to 21st.—Blackpool, Annual Conference, 1956.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Tues., Sept. 18th.—GLASGOW BRANCH: Visit to Babcock and Wilcox Renfrew Factory, 7 p.m.

Thurs., Sept. 20th.—KENT BRANCH: County Hotel, Canterbury, "Nightstor Heater," R. Fielding, 8 p.m.——SOUTHAMPTON BRANCH: Canute Room, Polygon Hotel, Southampton, "Some Problems in Sound Production," F. H. Brittain, 8 p.m.

Sat., Sept. 22nd.—OXFORD, READING AND DISTRICTS BRANCH: Collier Lecture Room, Regents Park College, Pusey Street, Oxford, "The Control of Automation," L. Meeks, 6.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 26th.—LONDON BRANCH: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Some Aspects of Transistor Progress," H. W. Loeb, 6.30 p.m.

Thurs., Oct. 4th.—N.W. SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "Education for Electronics," R. H. Garner, 6.30 p.m.

Fri., Oct. 5th.—S. MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, "Television Lighting Effects," A. E. Robertson, 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Sept. 24th.—LEEDS CENTRE: Griffin Hotel, Boar Lane, Leeds, Annual Dinner and Chairman's Induction; Visit of President, W. E. Harper, 7 p.m.——LEICESTER CENTRE: E. Midlands Electricity Board, Charles Street, Leicester, "Interesting Lighting Jobs," papers by Centre Members, 6 p.m.

Wed., Sept. 26th.—TRANSVAAL CENTRE: Room 95, Public Library, Johannesburg, Chairman's Address, R. S. Yates, 8 p.m.

Fri., Sept. 28th.—BATH AND BRISTOL CENTRE: Royal Hotel, Bristol, "Lighting for Enjoyment," T. O. Freeth, 7 p.m.——BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, Chairman's Address, V. A. Heydon, 6 p.m.

INCORPORATED PLANT ENGINEERS

Wed., Sept. 19th.—KENT BRANCH: Kings Head Hotel, High Street, Rochester, "The Corrosion of Iron and Steel and Remedial Measures," F. S. Bricknell, 7 p.m.

Thurs., Sept. 20th.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "The Maintenance of High Efficiencies on Economic Boilers," I. S. Groundwater, 7.30 p.m.

Mon., Sept. 24th.—WEST AND EAST YORKS. BRANCH: The University, Leeds, "Radiography in Industry," E. L. Grimwade, 7.30 p.m.

Thurs., Sept. 27th.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, Talk on a Large Civil Engineering Project, 7.30 p.m.

Fri., Sept. 28th.—S. WALES BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, Films, "Lubrication and its Importance in Plant Engineering," 7.15 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 19th.—26, Portland Place, London, W.1, "Diesel Combustion Study by Infra-Red Emission Spectroscopy," W. T. Lyn, 5.30 p.m.

Wed., Oct. 3rd.—26, Portland Place, London, W.1, "Le Havre-Paris Pipeline," J. B. Capdeville, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Sept. 25th.—PUBLIC HEALTH AND B.N.E.C. MEETING: Great George Street, Westminster, London, S.W.1, "The Problem of Liquid and Gaseous Effluent Disposal at Windscale," F. R. Farmer, 5.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Fri., Sept. 21st.—MANCHESTER AND DISTRICT BRANCH: Engineers' Club, Albert Square, Manchester, "Intermittent Heating in Buildings," E. Harrison, 6.30 p.m.

Tues., Sept. 25th.—BIRMINGHAM AND DISTRICT BRANCH: Exchange and Engineering Centre, Stephenson Place, Birmingham, "Electric Floor Heating," T. F. Cadman, 6.30 p.m.——SCOTTISH BRANCH: Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, "Principles for the Selection of Mechanical Stokers for Boiler Plant," E. J. Macdonald, 7 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 26th.—GENERAL MEETING: Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Presidential Address, J. F. B. Vidal, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Thurs., Sept. 20th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Mechanical Handling," F. T. Dean, 6.45 p.m.——SOUTHERN BRANCH: Royal Aircraft Establishment Technical College, Farnborough, Hants, "A Standard Gas Turbine to Burn a Variety of Fuels," G. B. R. Feilden, J. D. R. Thorne and M. J. Kemper, 7.30 p.m.——SCOTTISH BRANCH, GRADUATES SECTION: Visit to Brown Bros. and Co., Ltd., Edinburgh, 7, 7 p.m.

Wed., Sept. 26th.—E. MIDLANDS BRANCH: Technical College, Lincoln, Reception by the Chairman, G. B. R. Feilden, 6.15 p.m.; Chairman's Address, 7 p.m.——YORKSHIRE BRANCH: Visit to W. C. Holmes and Co., Ltd., and Holset Engineering Company, Ltd., 2.30 p.m.; Technical College, Huddersfield, "The Influence of Some Design Factors on the Characteristics of Ball-Bearings and Roller-Bearings at High Speeds," A. Fogg and J. S. Webber, 7 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Oct. 11th.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "Scale Effect Experiments on Victory Ships and Models," Part II, "Analysis of Wake Measurements on a Model Family and the Model Boat, D. C. Endert, Jr.," J. D. van Manen, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Sept. 17th.—COVENTRY SECTION: Craven Arms, High Street, Coventry, "Development of German Transfer Machines," Film and Discussion, 7 p.m.—MANCHESTER SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, "CO_2 Process Applied to Core Making," A. Talbot, 7.15 p.m.

Wed., Sept. 19th.—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Film Evening, "Automation," 7 p.m.——WOLVERHAMPTON GRADUATE SECTION: Technical College, Wulfruna Street, Wolverhampton, "High-Speed Press Work," J. A. Grainger, 7.30 p.m.

Tues., Sept. 25th.—OXFORD SECTION: Town Hall, Oxford, "Industrial Finishing Technique and Practice (Paints and Organic Coatings)," J. J. Stordy and W. G. J. Appleton, 7.30 p.m.

Wed., Sept. 26th.—SHREWSBURY SECTION: Technical College, Shrewsbury, "The Practical Application of Job Evaluation," E. H. Collins, 7.30 p.m.

Thurs., Sept. 27th.—NORTHERN IRELAND SECTION: Kensington Hotel, College Square East, Belfast, Chairman's Address, J. G. Easterbrook, 7.30 p.m.

IRON AND STEEL INSTITUTE

Thurs. and Fri., Oct. 4th and 5th.—IRON AND STEEL ENGINEERS' GROUP: Thursday: Grand Pavilion, Porthcawl, "The Engineering Aspects of a Modern Basic Bessemer Plant," C. Herrmann, 9.30 a.m. to 12.15 p.m.; Seabank Hotel, Porthcawl, Luncheon, 12.30 p.m. to 1.30 p.m.; Visit to Margam (Blast Furnaces, Coke Ovens and Sinter Plant) and Abbey (Open-Hearth Steel Plant and Wide Strip Mills), Works of the Steel Company of Wales, Ltd., 1.45 p.m. to 4.45 p.m.; Staff Restaurant, Abbey Works, Dinner, 7.30 p.m.; Friday, Grand Pavilion, Porthcawl, "The Planned Changeover of a High-Lift Slabbing to a Universal Mill," C. E. H. Morris and R. N. Dale, 9.30 a.m. to 12.15 p.m.; Esplanade Hotel, Porthcawl, Luncheon, 12.30 p.m. to 1.30 p.m.; Visits to Margam and Abbey Works of the Steel Company of Wales, Ltd., 1.45 p.m. to 4.45 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Oct. 11th.—The Temple, Dale Street, Liverpool, Presidential Address, W. Rose, 7 p.m.

OLD CENTRALIANS

To-day, Sept. 14th.—The Mapleton Restaurant, Coventry Street, London, W.1, "Cathodic Protection," H. G. B. Nolan, 12.45 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, Sept. 14th.—MIDLAND SECTION: Regent House, St. Phillips Place, Colmore Row, Birmingham, 3, "The Instrumentation of a Space Vehicle," N. R. Nichol, 7 p.m.

Tues., Sept. 25th.—MAIN MEETING: Manson House, Portland Place, London, W.1, Presentation of the Bowen Prize, "The Accurate Calibration of Flowmeters," E. A. Spencer and A. T. J. Hayward, 6.30 p.m.

Wed., Sept. 26th.—CHESTER SECTION: Chester and District Hospital Committee, 5, King's Buildings, King Street, Chester, "A Nuclear Power Station and its Instrumentation," K. R. Sandiford, 7.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Oct. 19th.—39, Elmbank Crescent, Glasgow, Symposium on the Application of Low-Alloy Steels for Welded Pressure Vessels, 10 a.m.